Member A.B.C—A.B.P.

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A MAGAZINE OF METHODS FOR OPERATING MEN

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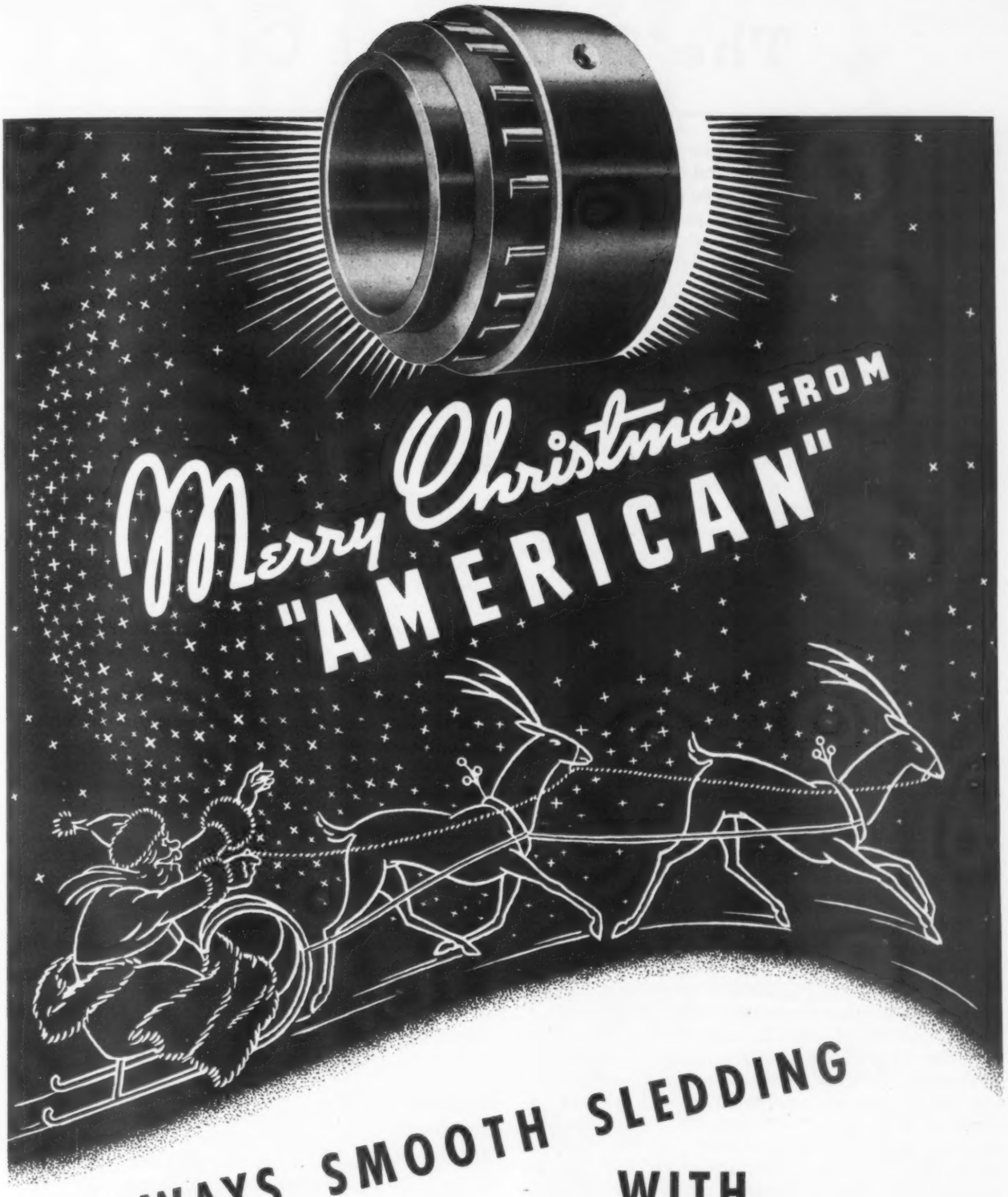

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The Course of Oil

By K. C. SCLATER

Would Impede Progress Many trained observers think that the Cole Bill for federal regulation of the oil industry will not be passed in its present form and that if passed, it will not be during the present session of Congress. Be that as it may, it seems certain that the industry and its operations are likely to come in for more scrutiny than usual from the Federal Government. Oil being a natural resource and one that cannot be replaced, it would be folly to assume that proponents of federal regulation will relinquish their efforts for some form of legislation.

In no uncertain terms has the oil industry reiterated its opposition to such legislation. The unanimity of opinion in the industry on this point is overwhelming. The progress made in recent years in state regulation of oil production, despite vicissitudes, needs no apologies. From all ranks and branches of the industry have come the emphatically expressed conviction that further federal regulation is unnecessary, that such regulation would impede progress, that it might lead to a restriction of the free play of economic factors, and would be detrimental to the industry, the public, and the nation.

Salt Water Problem The problem of salt water disposal in the East Texas field is assuming alarming proportions. By the end of 1941 the field will be producing 300,000 barrels of salt water daily; so estimates Chief Engineer Patton of the Railroad Commission. Even now, 150,000 barrels of salt water daily is being produced with the oil and 17,000 barrels of that is being reinjected into the pay sand, but that is not enough. Unless salt water is returned to the sand in larger volume the field will suffer.

Another phase of this problem has arisen with regard to allowables. Persistent requests have been made to the Railroad Commission to take into consideration the westside wells and the amount of water they produce. It is contended that the eastside wells are benefiting at the expense of the westside wells and that some compensation in proration allowance should be made. The problem of salt water disposal is, to say the least, a difficult and far-reaching one but no less so than the reconciliation of the interests of operators producing small amounts with those of operators producing large amounts of salt water. So far as reservoir conditions are concerned it might be better to require either curtailment of the amount of salt water produced or the reinjection into the sand of that produced. Whether salt water can be shut-off effectively by cementing or other means would in many wells be problematical. Nevertheless, some such method would seem to be desirable, but whether at this late stage the expense would be justified is not known, for the cost of doing this in a large number of wells might be prohibitive to the operator, and there would be no assurance of success. On the other hand it is to be remembered that every barrel of fluid raised to the surface means energy expended. This expenditure of energy, if taken from the natural energy in the reservoir, shortens the flowing life of the field. It brings nearer the day when the oil will have to be pumped.

Here is one instance where coöperative action and concerted efforts by operators, if taken in time, might have obviated the need for extreme measures for salt-water disposal and reconciling the problem of disparity between westside and eastside wells that now seems to have overtaken the field.

Field Allocation Plan New plans of proration are continually being devised and suggested. One of the most recent of these has to do with depletion of reserves in the reservoir. Under such a plan allowables among fields would be allocated on a basis of the volume of oil originally in place underground in the respective fields.

Although a departure from plans now in use, the adequacy of such a plan in meeting conditions found in actual practice is worth investigation and trial. Original reservoir content would include oil, gas, and natural expulsive energy. A field should be produced at a prescribed allowable rate and this rate should be the optimum, or at least somewhere near the optimum.

Both these considerations, original reservoir content and optimum rate of production, are fundamental. The optimum rate of production would be governed by energy and physical conditions in the reservoir. This factor could and should be adjusted by following an economic well-spacing pattern.

It is significant that this basis has been suggested and is now being investigated by engineers for application. Arbitrary methods of allocation based on the potential capacity of a well to produce without taking into consideration the size of the reservoir from which it draws and the physical conditions and energy relations therein, will, in time, be superseded by methods based on more fundamental factors. The plan of allocating allowables among fields on a basis of original reservoir content is a trend in this direction.

Employer-Employee Relations Early this year THE PETROLEUM ENGINEER took upon itself the task of making a survey of working and living conditions and average prevailing wages in the industry. The results of this survey have been covered in a comprehensive article *"This Industry of Ours"*, in four parts, the last of which appears in this issue.

Public relations in the oil industry are assuming a place of rightful importance. An important phase of this subject is that of personnel relations. The harmonious relations that exist between employer and employee in the oil industry are based upon a mutual respect and consideration between the company and the worker. In this regard the oil industry has an enviable record.

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« « HIGHLIGHTS IN OILDOM » »

Kansas Revises Proration Regulations

The Kansas State Corporation Commission has issued revised rules and regulations designed to assign proration more equitably.

Principal changes involve the temporarily-suspended top well potential rule and the double acreage factor in determining daily allowable. The log-log curve depicting the mathematical formula for computing allowables between pools is retained but has a new classification table.

The order became effective December 1, and is the result of hearings held during November at which operators and engineers asserted flush production areas were discriminated against under existing regulations.

The new order reinstates the 15-bbl. minimum potential, no 30-bbl. minimum being allowed for wells on twice the acreage, as previously authorized. The acreage on which the well is located will be considered, however, in determining production allowables on a "productivity" basis, a combination of the well potential and the acreage it drains.

"New classifications under the log-curve method are expected to give a higher percent of production to the larger pools," Attorney Harold Medill stated in making the rules public.

The Kansas Corporation Commission will maintain closer supervision over the taking of potentials in an effort to "increase accuracy and fairness," it is stated.

Producers will still be given their choice of potential test methods. Only minor changes will be made in the manner in which potentials shall be taken and reported.

●

Pennsylvania Crude Oil in New Price Advance

Continued active demand has resulted in another price advance for Pennsylvania crude oil. This is the third increase within a period of two months and the sixth this year.

The price advance was 10 cents a bbl. and was announced by the Joseph Seep Purchasing Agency of the South Penn Oil Company, the Quaker State Oil Refining Corporation, and the Pennzoil Company.

The new prices are: Bradford and Allegheny crude oil, $2.50 per bbl.; Southwest Pennsylvania, $2.15; Eureka, $2.09, and Buckeye, $2.05.

●

Total Value Crude Oil Declined in 1938

According to the final summary of petroleum statistics for 1938 recently issued by the U. S. Bureau of Mines, the total value of crude oil produced in the United States in 1938 declined nearly 10 percent from the 1937 total. The value in 1937 was $1,513,340,000, whereas in 1938 it was $1,367,060,000. The decline in total value at the well reflects a 5 percent decrease in the volume of crude oil produced and a 4.2 percent decline in the average value per bbl. to $1.13 from $1.18 in 1937.

Production, demand, and stock figures for crude oil and the major petroleum products in this final report reveal only minor revisions of previously-published estimates; nearly all changes being slightly upward.

Total crude oil production in 1938, according to these final data, was 1,214,355,000 bbl., an increase of 1,101,000 bbl. from the preliminary estimate.

Demand for all petroleum products totaled 1,330,851,000 bbl., of which 1,137,123,000 bbl. were consumed domestically.

Besides the total value and average price per bbl. data, the report gives for the first time a summary of wells drilled by months, the number of producing wells by states, and the average production per well per day. The number of producing wells increased from 363,030 on December 31, 1937, to 369,640 on December 31, 1938, a gain of slightly less than 2 percent, although 19,121 of the 27,149 wells drilled in 1938 found oil. Average production per well per day declined from 9.8 bbl. in 1937 to 9.1 bbl. in 1938. The average showed a marked variation, from 0.2 bbl. per well per day in northwestern Ohio to a 145.5-bbl. average per day for the wells on the Louisiana Gulf Coast.

●

Pressure Decline In East Texas Wells Slackens

Texas Railroad Commission officials reported on December 11 that tests on 69 wells in the East Texas field showed an average bottom-hole pressure decline of 5.11 lb. for the previous month. East Texas pressures declined an average of 20 lb. during the month ended November 8, causing considerable concern. Engineers asserted that many wells would have had to go on the pump had the decline continued so rapidly.

●

Seeks Meeting Of Governors To Oppose Federal Control

Chairman Lon A. Smith of the Texas Railroad Commission stated recently that officials of oil-producing states had responded favorably to his suggestion for a meeting in Washington after Congress convenes. The Cole Committee, he said, will be requested to schedule another hearing in Washington. Should that not be done, however, plans will not be abandoned for a meeting of oil states officials there.

The proposed meeting would be one of governors of the oil-producing states, Smith said. Although he personally dispatched letters to the various officials to test sentiment, Smith asserted he would place the matter before Governor W. Lee O'Daniel and suggest that the latter take the initiative.

The proposed meeting would be to further the campaign of the states against federal control. It is believed by Commissioner Smith that a meeting in Washington would prove advantageous to the petroleum industry in that it would then be possible to "bring testimony directly before members of Congress, who must decide the issue."

Smith stated that favorable replies had been received from officials in Oklahoma, Kansas, California, Michigan, and New Mexico.

●

Y.P.F. Receives Bids for Drilling Wells

On December 22, bids will be opened in the New York office of the Yacimientos Petroliferos Fiscales (Y.P.F.) for the drilling and completion of from 70 to 100 wells in the Comodoro Rivadavia field, Argentina, in 1940. Specifications and an invitation to bid recently were sent to leading drilling contractors in the United States.

The Y.P.F. proposes that the contractors provide all equipment necessary to complete the wells drilled, a well being considered completed when its production is turned into the lease tanks. All such equipment will be permitted entry into Argentina duty free.

This is the first contract drilling program considered by Y.P.F. Heretofore the government has conducted its own exploitation to the exclusion of private interests.

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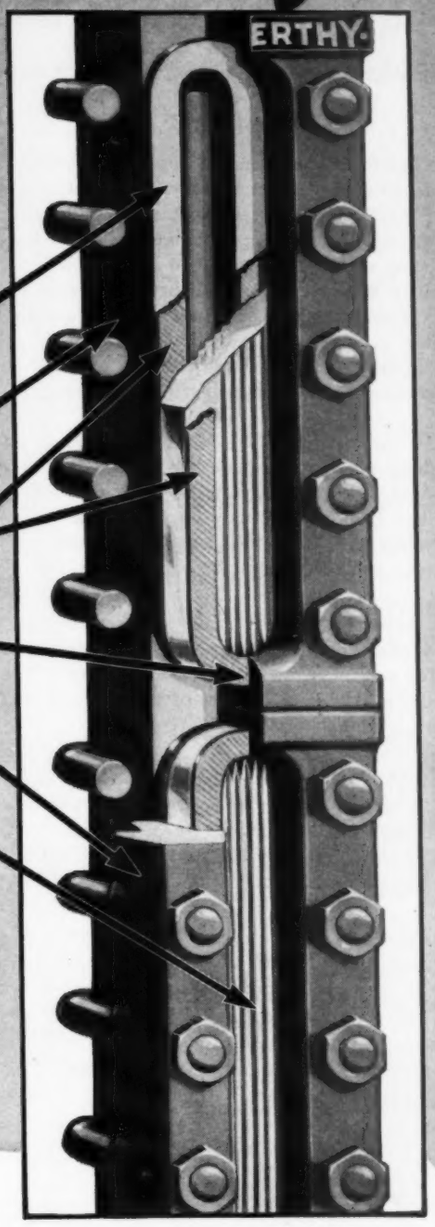

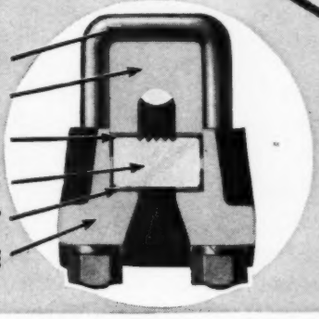

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Activities in Refining

Percent Refining Capacity Operated

Western Division, 70.1 Percent **Central Division, 73.1 Percent** **Eastern Division, 91.3 Percent**

THE Indiana Farm Bureau Coöperative Association, Inc., plans the construction of a 2500-bbl. refinery at a site on the Ohio River northwest of Mount Vernon, Indiana. The proposal is to process principally Illinois and Indiana crude oil, but by being situated on the Ohio River it will be convenient to bring in crude from other areas by barge should it be desirable. River transportation will also be utilized in shipping refined products.

Ralph Booker, who is assistant manager of the oil division of the association, will be manager of the refinery.

●

Gas and Oil Products, Inc., recently placed in operation a new cracking unit at its refinery in the South Turner Valley field, Canada. The capacity of the unit is 800 bbl. per day and this can be stepped-up to 1500 bbl. per day. The new unit, together with the plant's topping and absorption equipment, gives a combined capacity of 4000 bbl. per day.

●

M. W. Kellogg Company is designing a 7000-bbl. hydroforming unit for the Pan American Refining Corporation, to be installed at its Texas City, Texas, refinery. The process involves the catalytic reforming of naphthas to high-octane motor fuel.

●

A 1500-bbl. skimming plant has been completed near Dupo, St. Clair County, Illinois, by the Transport Oil and Refining Company. It is situated in the extreme southwestern part of the state, adjacent to the Plank Road pool. A part of the crude oil supply will be obtained from that pool.

●

The Virginian Gasoline and Oil Company, Charleston, West Virginia, is installing a Perco catalytic desulphurization unit at its Cobb plant. Its capacity will be 1000 bbl. per day. The unit, which will be completed soon after the first of the year, will be operated under a license agreement with Perco, Inc.

●

Lone Star Gasoline Company, Dallas, Texas, has announced plans for the construction of a recycling plant in the Cayuga field, Anderson and Henderson counties, Texas. Lone Star and three other companies have pooled their acreage and are drilling three wells in the field. Distillate will be recovered and the residue gas returned to the producing formation.

The Advance Refining Company, Centralia, Illinois, has installed an ethyl-blending plant, said to be the first of its kind in the area. The unit was installed by the Ethyl Corporation under the supervision of its representative, B. G. Crane.

●

The Brazilian Government plans construction of a 4000-bbl. refinery at Nictheroy, capital of the State of Rio de Janeiro, it is reported. The plant will cost approximately $2,600,000 and will have topping and cracking units.

●

Peerless Purchasing Company, Detroit, Michigan, has completed a 1000-bbl. refinery at Kalamazoo, Michigan, the first to be constructed at that point. Crude oil supply will be from southwestern Michigan fields.

●

The Pantagon Refining Company is installing a new still and fractionating tower at its refinery at Starks, Michigan. This will increase the plant's capacity from 3000 to 4000 bbl. per day.

●

Imperial Oil, Ltd., recently completed a test run of its enlarged refinery at Fort Norman, Canada, after which it shutdown for the winter months. The plant now has a capacity of 800 bbl. per day; the old refinery had a capacity of 300 bbl. per day. Crude oil supply will be from wells in the Fort Norman field.

●

The Humble Oil and Refining Company has awarded a contract for reconditioning and altering its refinery at Corpus Christi, Texas, to the Brown and Root Construction Company. A part of the work will include the enlargement of the skimming and cracking units. Although complete details are not available, it has been announced that the program will involve the expenditure of several million dollars.

●

The Quaker State Oil Refining Corporation is installing a furfural solvent extraction unit at its refineries at Farmer's Valley, Pennsylvania, and St. Mary's, West Virginia. A similar unit will be installed at the company's Emlenton, Pennsylvania, refinery at a later date, it is announced.

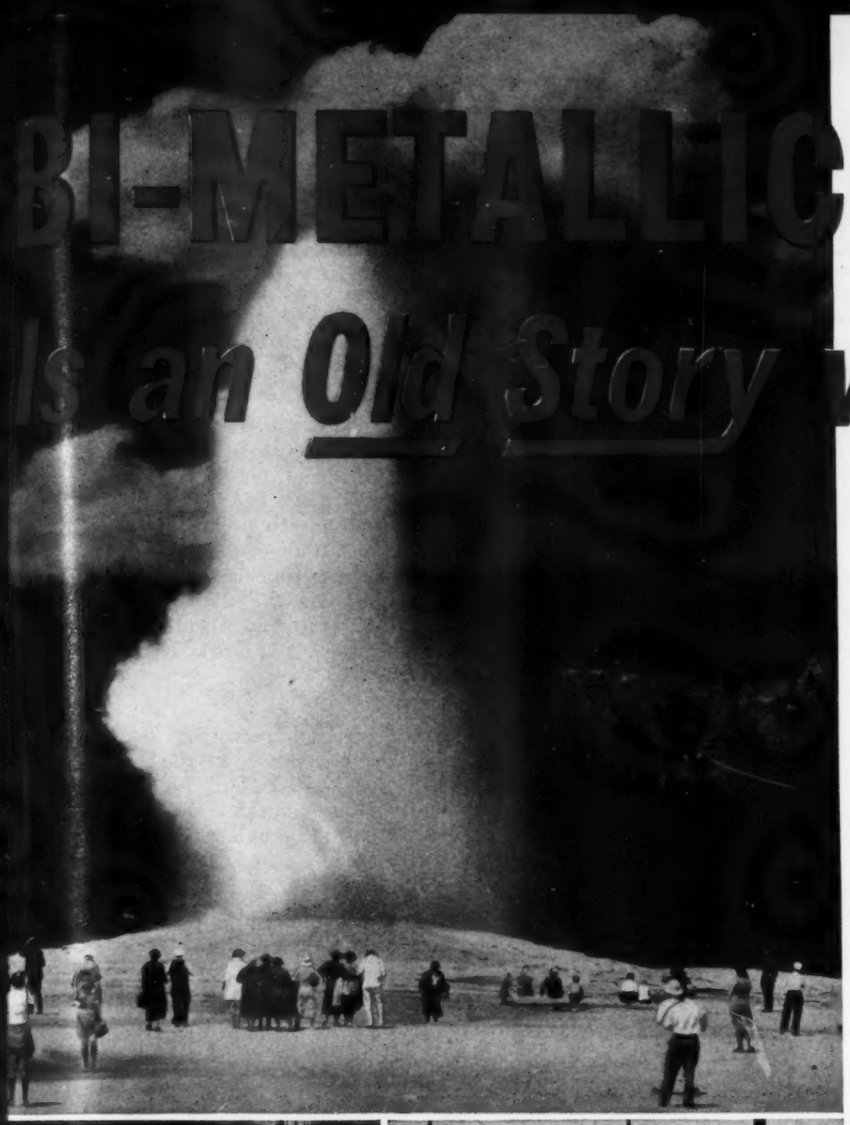
Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended December 2, 1939

A.P.I. Figures
(Figures in thousands of bbl. of 42 gal. each)

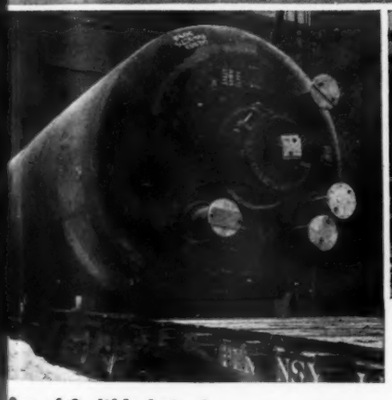
DISTRICT	Percent Potential Capacity Reporting	Daily Average Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	533	86.7	17,916	21,446
Appalachian	87.3	130	89.7	3,129	857
Ind., Ill., Ky.	90.7	571	97.6	11,219	7,597
Okla., Kans., Mo.	81.6	255	74.6	6,441	4,337
Inland Texas	50.3	104	65.4	1,686	2,182
Texas Gulf	90.0	798	84.0	11,326	12,860
La. Gulf	97.8	114	65.1	2,517	3,225
No. La. and Ark.	55.0	42	76.4	367	842
Rocky Mt.	54.2	46	71.9	1,061	576
California	90.0	522	70.1	15,353	91,321
Reported	86.4	3,115	81.2	71,015	145,243
Estimated Unreported	.....	365	.....	5,350	3,095
*EST'D TOTAL U. S. DEC. 2, '39	.....	3,480	.....	76,365	148,338
*EST'D TOTAL U. S. NOV. 25, '39	.....	3,510	.....	75,595	150,633
U. S. B. of M. *DEC. 2, 38	.....	**3,244	.....	69,604	150,135

*Estimated Bureau of Mines' basis. **November, 1938, daily average.

BI-METALLIC Construction Is an Old Story with Smith



BI-METALLIC construction, made in the A. O. Smith manner—in other words, *Smithlining*—was pioneered by A. O. Smith ten years ago. It is still the "Old Faithful" in the bi-metallic field for high-pressure, high-temperature service, universally used and accepted wherever there are corrosion problems. Better stick to "Old Faithful" for high-pressure vessels—lined or unlined. A. O. Smith Corporation, Milwaukee, Wisconsin. Offices at New York, Pittsburgh, Chicago, Tulsa, Dallas, Shreveport, Houston, Corpus Christi, Los Angeles.



One of Smith's Latest—a Class I high-pressure vessel, 13′-1-3/16″ inside diameter, 61′-7″ overall length, lined with Type 410 chrome alloy—one of the many different alloys for which Smithlining has been perfected. This vessel is of recent construction.

First Smithlined Pressure Vessel Ten Years in Service—The first high-pressure vessel with corrosion-resisting metallic lining ever to be placed in refining service was shipped to one of America's large refineries almost ten years ago to a day—November 26, 1929, to be exact. This vessel is still in service. Recent exhaustive inspection revealed it to be as serviceable as the day it was installed. This vessel is 5 feet in diameter and 41 feet in length. Its walls are 3 inches thick and Smithlined with 7/64 inch 18-8 stainless steel.

SMITH PRESSURE VESSELS

ASK SMITH ABOUT:

- **Contamination-proof joints**
- **Thermal conductivity**
- **Ability to take temperature changes**
- **Carbon migration**
- **Test of the lining**
- **Surface finish**
- **Stress corrosion**
- **Selection of lining material**

Smithlined Pressure Vessels have a tremendous metallurgical background. The above problems are not new to Smith. Their successful solution is one of the reasons why over 90% of the high-pressure vessels with corrosion-resisting linings now in service are of Smith manufacture.

A.O.SMITH CORPORATION

Milwaukee, Wisconsin

PIONEER MANUFACTURERS OF ELECTRIC-WELDED

Pressure Vessels

Casing · Line Pipe

Activities in the Oil Fields

NO. 1 Petty Stave of Standard Oil Company of Louisiana has opened a new pool 5 miles west of the Magnolia pool, Columbia County, Arkansas. The well is located in C SE SE of 4-17-21, and on a drill-stem test at a depth of 7940-69 ft. cleaned the hole of drilling fluid and blew mud and distillate. After the tools were pulled the drill stem showed 120 ft. of distillate cut with oil.

●

Several new oil pools have been discovered in Illinois recently. The discoveries were in Wayne, Washington, and Williamson counties. In Wayne County, Cuyuna Oil Company's No. 1 J. V. Borah, in 23-1s-8e, northeast of Fairfield, flowed 200 bbl. from the McClosky limestone after treatment with acid. Shell Oil Company's No. 1 Mary Dix, in NW NE NE of 19-3e-1w, near Du Bois, opened the Washington County pool. Production was from the Benoist formation at a total depth of 1370 ft., the well flowing 46 bbl. of oil in 24 hr. Williamson County was given its first oil production by Charles S. Nations, who brought in a well 9 miles southwest of Herrin that produced 25 bbl. of oil in 25 minutes. Total depth is 1990 ft. in the McClosky limestone. This discovery makes possible the development of a field 40 miles south of any proved Illinois area.

●

A new deep-producing area has been opened in St. Martin Parish, Louisiana, by Shell Oil Company's No. 1 Iberville Land Company, in section 86-7s-8e. The well flowed 15 bbl. of 39-gravity oil per hour through a 10/64-in choke. Total depth was 10,000 ft., perforations being at 9746-58 ft.

●

No. 1 Ross of Continental Oil Company, Superior Oil Company of California, and Red Dillard, a wildcat 5 miles northwest of the Bridwell-Halsell Strawn pool, western Clay County, Texas, was successfully completed in the Bend lime at a depth of 5350-5400 ft. Estimates place the well's potential at 1000 bbl. per day or greater.

●

Discovery of Devonian production in the Salem pool by Kingwood Oil Company is of importance to Illinois because it means an extended producing life for the state, immediate increase in drilling activity, and increased output for the state. The obtaining of oil from this prolific and deeper formation promises to take the state out of the shallow classification and place it on a longer time basis.

In the discovery well, No. 18-A J. O. Shanafelt, north of Jefferson, the Devonian was penetrated at a depth of 3345 ft., and the total depth of the well is 3502 ft. The well is rated at 1800 bbl. per day.

●

Kraft South pool, Barton County, Kansas, about one mile southwest of the Kraft pool, has been opened by the Shell Oil Company's No. 1 Herthel. The well, in CSE SW NW of 13-17-11w, is producing from the Arbuckle lime at a total depth of 3291 ft. The potential of the well is 176 bbl. per day.

●

Paul McIntyre and Associates have opened a new producing formation, the Booch sand, in an old pool near Weleetka, Okfuskee County, Oklahoma. Their No. 2-A Steil, in C N½ SW of 18-10-11e, flowed 11½ bbl. of oil per hr. and 6,000,000 cu. ft. of gas through casing, the total depth being 2183 ft. Most of the wells have been plugged. A few are still producing from the Simpson; this is the only Booch sand well.

AVERAGE CRUDE OIL PRICES

California		Louisiana	
Kettleman Hills	$1.19-1.43	Rodessa	$1.05
Playa Del Rey	.80-1.16	Gulf Coast	.79-1.28
Coalinga	.70- .90	North Louisiana	.73-1.05
Wilmington	.75-1.21	Illinois	.95-1.05
Montana	.90-1.10	Kentucky	.90-1.10
Wyoming	.35-1.30	Indiana	.95
Colorado	.90- .98	Ohio	
New Mexico	.53- .95	Lima	.90
Texas		Michigan	.74-.97½
North Central	.71-1.03	Pennsylvania	
Panhandle	.67- .96	Bradford	2.50
West Texas	.53- .95	Southwest	2.15
Gulf Coast	.86-1.28	Eureka	2.09
Darst Creek	.96	Buckeye	2.05
East Texas	1.10	Corning	1.12
Talco	.65	Canada	2.10-2.17
Kansas	.60-1.10		
Oklahoma	.60-1.10		
Arkansas	.73-1.05		

Daily Average Crude Oil Production
Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

	[1]B. of M. Calculated Requirements (November)	Week Ended Dec. 2, 1939	Week Ended Oct. 28, 1939	Week Ended Dec. 3, 1938
Oklahoma	429,000	[2]408,950	[3]415,750	417,550
Kansas	169,000	[2]177,250	[3]187,200	148,350
Nebraska	.....	[2] 50	.....	.....
Panhandle Texas	.....	61,150	64,000	62,350
North Texas	.....	74,100	76,100	73,950
West Central Texas	.....	24,700	27,500	30,200
West Texas	.....	184,950	208,600	205,950
East Central Texas	.....	79,350	83,550	90,950
East Texas	.....	299,000	395,500	371,150
Southwest Texas	.....	154,150	193,100	226,300
Coastal Texas	.....	183,050	202,550	211,950
TOTAL TEXAS	1,444,000	1,060,450	1,250,900	1,272,800
North Louisiana	.....	69,650	65,700	72,550
Coastal Louisiana	.....	202,550	199,150	188,350
TOTAL LA.	259,000	272,200	264,850	260,900
Arkansas	57,000	70,250	65,900	48,600
Mississippi	.....	[2] 1,250	800	.....
Illinois	303,000	330,950	340,400	200,850
Eastern (Not incl. Ill.)	106,000	105,750	103,100	
Michigan	63,000	65,150	63,950	50,650
Wyoming	63,000	70,250	62,100	53,400
Montana	16,000	17,050	17,200	12,050
Colorado	4,000	4,000	3,900	3,600
New Mexico	111,000	110,750	115,750	108,200
TOTAL EAST OF CALIF.	3,024,000	2,694,300	2,891,800	2,576,950
California	596,000	594,900	606,700	646,700
TOTAL U. S.	3,620,000	3,289,200	3,498,500	3,223,650

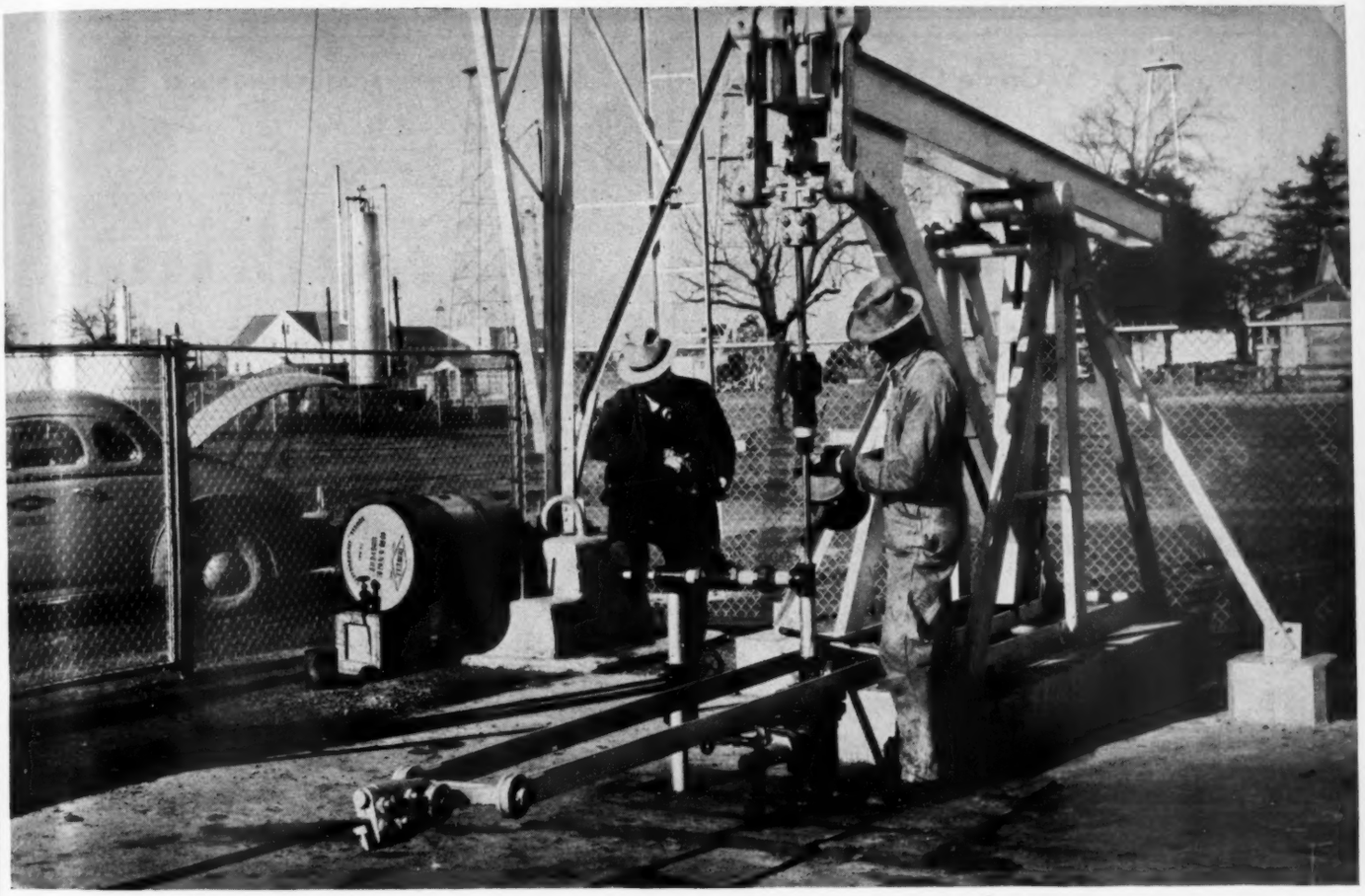
[1]These are U. S. Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of November. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

[2]Oklahoma, Kansas, Mississippi, and Nebraska figures are for the week ended 7 a. m., November 29.

[3]Oklahoma and Kansas figures are for the week ended 7 a. m., October 25.

The American dye industry no doubt would rank The Dow Chemical Company's development of synthetic indigo as Dow's most outstanding achievement. For it was Dow's extensive research that produced, in 1916, the first synthetic indigo on a commercial basis, thereby freeing this country from foreign monopoly and marking the beginning of the great American dye industry.

DOW



● The same vast research and technical ability that produced indigo commercially, thereby establishing our American dye industry, collaborated in the development of Dowell's "famous family" of Paraffin Solvents—the most effective, efficient and economical paraffin removers available.

This famous family of solvents includes **DOWELL ORANGE** for removal of the purer types of paraffin; **DOWELL RED** for dissolving not only pure but impure deposits containing asphalt and sulphur; **DOWELL BLUE** (a non-corrosive solvent containing no chlorine or sulphur compounds) efficiently removes the relatively pure and also the asphaltic base paraffins.

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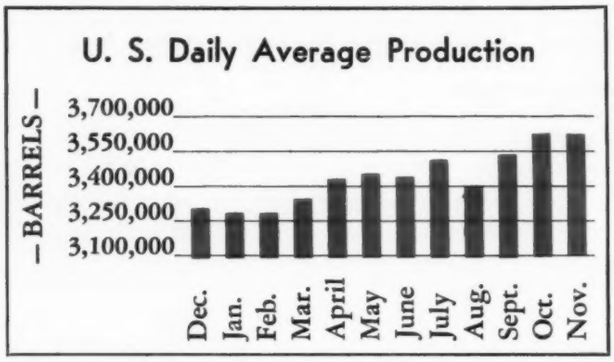
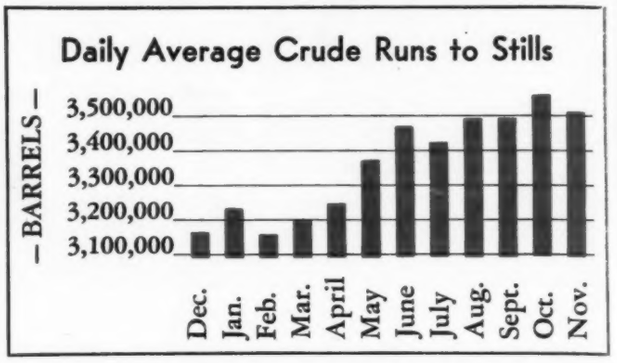
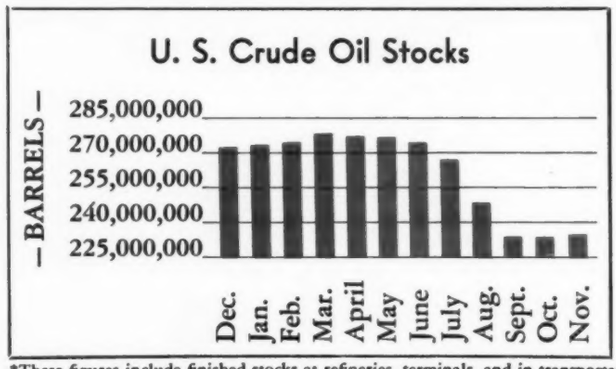
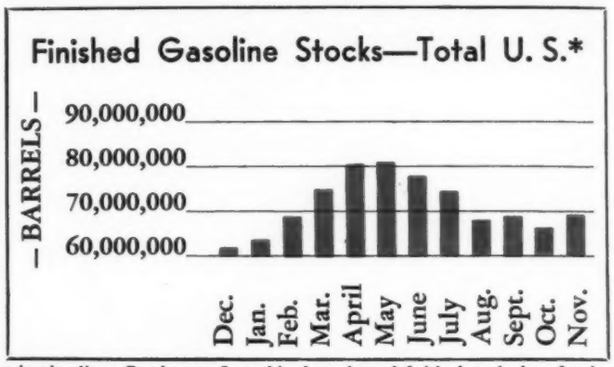
OIL AND GAS WELL
CHEMICAL SERVICE

Petroleum Statistics and Field Activities









*These figures include finished stocks at refineries, terminals, and in transportation in pipe lines. Previous to June this chart showed finished stocks in refineries only. Above statistics by the American Petroleum Institute.

Summarized Operations in Active Fields for November, 1939

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
Texas								
East Texas	26	26	5	12	3500-3700	2	40	Rotary
Duval County	33	26	3	14	1554-2900	2	22	Rotary
Ector County	40	30	12	59	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	56	56	20	65	1700-3900	2	40	Rotary
Refugio County	9	8	2	6	4900-5900	2	38	Rotary
Nueces County	21	18	6	12	3922-5878	2 or 3	21-54	Rotary
Winkler County	6	6	2	4	2850-3450	2 and 3	30-38	Rot.-Cab.
K. M. A. Field	33	33	28	40	3730-3935	2	42-43	Rot.-Cab.
Oklahoma								
Oklahoma City	2	2	1	2	6450-6682	3	39	Rotary
Fitts Pool	9	7	2	10	1800-4488	2 or 3	38	Rotary
Kansas								
Russell County	27	25	6	28	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	20	16	5	25	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	16	14	6	20	3290-3518	2	39-42	Rot.-Cab.
Illinois								
Central Illinois	441	354	331	119	1425-4100	2	36-38	Rot.-Cab.
New Mexico								
Lea County	36	33	10	53	3150-4030	3	30-34	Rot.-Cab.
California								
Kettleman Hills	4	4	1	17	8300-8730	3 or 4	40	Rotary
Wilmington	20	20	15	14	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for November, 1939

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1938 (In Barrels)
	November	October	November	October	November	October	November	October	November	October	
Arkansas	15	19	13	11	26	13	24	20	33	31	18,211,617
California	117	100	107	87	209	115	98	94	215	197	249,918,001
Colorado	1	4	0	3	....	....	2	3	34	35	1,371,687
Illinois	366	321	286	266	488	....	300†	326**	97	115	23,306,000
Indiana	51	44	40	39	....	....	10	12	69	61	965,900
Kansas	149	153	114	121	256	189	52	37	275	193	58,795,545
Kentucky	64	50	38	29	....	....	12	10	106	104	5,828,650
Louisiana	135	144	97	108	188	142	....	45	....	167	94,941,537
Michigan	124	158	76	91	153	147	46	22	172	158	19,140,966
Mississippi	4	3	2	2	....	....	7	9	14	10	Gas Prod.
Montana	16	18	11	14	....	....	3	2	41	40	4,858,458
New Mexico	62	75	56	62	65	89	21	16	140	136	39,902,263
New York	96*	74*	96*	74*	....	....	7	8	43	41	5,040,600
Ohio	110*	91*	74*	66*	....	....	44	37	192	195	3,292,100
Oklahoma	190	251	123	173	221	207	40	36	312	291	171,312,098
Pennsylvania	142*	116*	140*	107*	....	....	....	....	....	....	17,431,500
Tennessee	0	4	0	2	....	....	....	....	....	....	....
Texas	847	853	640	653	1044	1069	375	377	1202	1197	473,304,662
West Virginia	68	55	56	47	....	....	21	24	149	129	3,700,375
Wyoming	14	17	11	11	....	....	5	3	69	74	19,005,638
Total	2572	2546	1980	1964	2650	1670	1067	1081	3163	3174	1,206,827,597

*Inludes water-intake and pressure wells.
**Includes 302 rigs standing and 24 rigging-up.
†Includes 257 rigs standing and 43 rigging-up.

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With the Nixon Gas-Lift System you have complete control of production with the surface equipment. You can change the volume of flow—produce from a higher or lower fluid level—change from intermittent to constant flow, or vice versa, without disturbing the sub-surface setting.

It is the only Patented Gas-Lift System on the market that will operate successfully in any kind of fluid well.

It is the only closed Gas-Lift System equipped with a series of mechanically operated unloading valves. The unloading valve—located at the most advantageous producing level—becomes the actual Flow Valve, which is mechanically opened and closed by the automatic intermittent surface equipment. With this system the gas pressure used for producing the well, is kept entirely off the producing formations.

Expensive pumping units and their costly installations and maintenance are no longer necessary. The Nixon System will produce wells from the ceasing of natural flow to their depletion.

The complete story will convince you the Nixon System is the modern economi-cal way to raise fluid. Talk to one of our Gas-Lift engineers soon. Write your nearest Wilson Supply Company store or sales office.

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EXCLUSIVE GULF COAST DISTRIBUTORS FOR: Wilson-Snyder Pumps; American Cable Tru-Lay Pre-formed Wire Rope; Kewanee Boilers; Sievers Reamers; Drift Meter, Jr.; Gray Swivel; Nixon Surface Control Gas Lift; Nixon True-Taper Slip and Spider; Bowen Pack-Off and Releasing Drill Pipe Overshot; Douglas Weight Indicator.

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BRANCH STORES:
TEXAS: Gladewater; Barbers Hill; Bay City; Monahans; Alice; Victoria; Corpus Christi; Benavides; Arkansas City.
LOUISIANA: Rodessa; Lake Charles; New Iberia; Gretna; Shreveport.
ARKANSAS: Magnolia.
SALES OFFICES: Tulsa, Oklahoma; Dallas, Texas.

Major Pipe Line Activities

A 6-in. pipe line extending 93 miles from the Wasson-Bennett field of Gaines and Yoakum counties, Texas, to Big Spring will be in operation the early part of 1940, according to present plans.

The Basin Pipe Line Company has been formed, the directors of which are C. L. McIver, Fort Worth; Henry Zweifel, president of the Cosden Petroleum Corporation, and Myron G. Blaylock, attorney of Houston and Longview.

Survey of the right-of-way has been completed, the line to run in a southeasterly direction from Wasson-Bennett to Big Spring. Laterals may be laid to the Seminole field of Gaines County and to the Cedar Lake area of northeastern Gaines County. At present the former field has no pipe-line outlet.

Cosden Petroleum Corporation has contracted to take the crude oil transported by the line for a period of five years, to help supply its 15,000-bbl. refinery at Big Spring. Some difficulty has been experienced in recent months in obtaining sufficient crude oil to keep the plant operating at capacity. It is stated that crude oil has been contracted from the Continental Oil Company, Texas Pacific Coal and Oil Company, Honolulu Oil Corporation, Basin States Oil Company, and Amon G. Carter.

●

The 450-mile gasoline pipe line from Port St. Joe, Florida, to Atlanta, Georgia, will be owned jointly by the Gulf Refining Company and the Pure Oil Company, and will be constructed and operated under the name of the Southeastern Pipe Line Company.

The line will be of 6⅝-in. and 8⅝-in. pipe and the project will cost from $5,000,000 to $7,000,000.

Gasoline will be transported to Port St. Joe by tanker from the Gulf's refinery at Port Arthur, Texas, and Pure's refinery at Smith's Bluff, Texas.

Williams Brothers Corporation, Tulsa, Oklahoma, was awarded the construction contract, and operations will be under the supervision of Guy S. Connors. Deliveries of pipe were scheduled to begin December 15. The line will be laid by the "stove-pipe" method and will be electric welded throughout. Four pumping stations and ten bulk stations will be constructed.

Operation of the line will be in charge of the Gulf Refining Company.

●

A certificate of convenience has been received from the Arkansas Corporation Commission by the Louisiana-Nevada Transit Corporation for construction of a gas pipe line from the Cotton Valley field, Louisiana, to Hope, Arkansas. Approximately 85 miles of 8-in. pipe will be used in the line, 12 miles of 6-in., and some 4-in. or smaller.

W. A. Delaney, Ada, Oklahoma, and T. R. Jones, Dallas, Texas, are the owners of the Louisiana-Nevada project.

●

The Texas-New Mexico Pipe Line Company is increasing the capacity of its line serving the Artesia district, Eddy County, New Mexico, by replacing 22 miles of 5½-in. pipe with 8-in. The 8-in. pipe will extend from a point near the Eddy-Lea county line southeast to Lynch station where it will tie-in with a 6-in. line. The present capacity of 7,000 bbl. thus will be increased to 10,000 bbl. per day.

The company is taking up 18½ miles of 8-in. pipe between the Vacuum field and the Lynch station to use on the new project.

The Southern California Gas Company is laying a number of loops and making certain other changes to increase the capacity and operating efficiency of its system. A 5½-mile, 10-in. loop between Kettleman Hills and Lemoore Junction will increase delivery capacity to the Visalia and Fresno districts. A 5-mile, 8-in. loop has been completed between Lemoore Junction and Visalia. The 12-in. Ventura gas line has been relocated to prevent possible washout by flood waters. Between the Rio Bravo field and the Greeley and Ten Section pipe line an additional 1½ miles of 8-in. pipe have been laid to take natural gas from the Union Oil Company's Rio Bravo absorption plant and transmit it to the Los Angeles Basin.

●

Williams Brothers Corporation, Tulsa, Oklahoma, has been awarded a contract by the Michigan Gas Producing Company to lay a 40-mile, 8-in. gas pipe line connecting the Muskegon field, Michigan, with several Michigan towns.

●

The Santa Maria Gas Company, Los Angeles, California, has completed a 12-mile, 10-in. gas line connecting the Morro Bay area with the company's gas-distributing facilities.

●

The Magnolia Petroleum Company has begun construction of a crude-oil and refined-oil terminal at Corpus Christi, Texas. Thirteen all-welded steel storage tanks will be erected on a 53½-acre site on the ship channel.

Magnolia has an 8-in. crude oil line terminating at Corpus Christi and this crude will be shipped through the terminal to refineries on the Gulf Coast, the refined products to be returned by tanker and distributed in the area.

The project is expected to be completed by February 15. The Chicago Bridge and Iron Works Company has been awarded the contract.

●

Humble Oil and Refining Company is constructing an 8-mile pipe line from the Colorado field, Jim Hogg County, Texas, to the Charco Redondo field, where it ties-into a line connected with port facilities at Ingleside.

●

Directors of the Panhandle Eastern Pipe Line Company have authorized the expenditure of $3,500,000 for new construction, J. D. Creveling, president, has announced. The work will include construction of 142 miles of 22-in. and 24-in. loops to the company's trunk system. New compressor equipment also will be installed, and the capacity of the company's combination natural gasoline and dehydration plant will be increased.

The company's lines transport natural gas from Texas and allied fields to consumers in Michigan, Illinois, Missouri, Kentucky, Indiana, and Kansas.

●

Extensions to the system of the Valley Pipe Line Company, McAllen, Texas, are well under way. A total of 70.63 miles of new line will be laid. One extension north and east from the present El Tanque field terminus of the company's main line connects the Rincon and Sun fields, eastern Starr County, and the Alta Mesa field, southwest Brooks County. Another connects the Guerra field, northwest Starr County.

P 615.2

THE Petroleum Engineer

DECEMBER, 1939

Design and Construction of Oil Pipe Line in Rocky Mountain Area

Stove-pipe welding is used throughout—pump speed is automatically controlled by suction pressure—greater part of pumping energy will be consumed on steep mountain slopes

By H. LEE FLOOD
Associate Editor

THE oil pipe line recently completed by Utah Oil Refining Company in Wyoming and Utah is one of the most interesting projects of this type undertaken in years. Constructed from Fort Laramie, Wyoming, to Salt Lake City, Utah, the 442-mi. main line is in mountainous country over most of the route and is the first pipe line to cross the Continental Divide.

The line was built and is to be operated for the owner-company by Stanolind Pipe Line Company. Both companies are subsidiaries of Standard Oil Company (Indiana). The purpose of the line is to provide a connection between lines from Lance Creek to Fort Laramie and Utah Oil Refining Company's refinery at Salt Lake City. Other Wyoming oil will be received into the line enroute, at Medicine Bow and Granger stations.

First pipe was strung along the right-of-way on August 10, 1939. All schedules had been completed by November 10. Completed in the elapsed time of 93 days, this is a remarkable record of speed and efficiency in pipe-line construction. Main-line construction was awarded to four contractors in the amounts of 182 mi., 140 mi., 74 mi., and 45 mi., respectively.

Pipe-Line Construction

Reconnaissance. The country traversed by the new line is perhaps the most rugged ever encountered in a project of such magnitude. The accompanying profile shows that both end sections of the line are inclined steeply; the center sections of the line are at high elevations only relatively less steep than the end sections.

A more favorable route from a topographical consideration alone would have been slightly north of the route selected. In this sparsely inhabited region, however, proximity to railroads and to established highways and communities are factors important enough to weigh heavily in determining the more economical route.

Several days were occupied by representatives of the company and interested contractors in flying above the region, scanning the country for possible routes. Aerial maps were obtained of the entire route, thus permitting a rapid study of the topography otherwise virtually unattainable.

Construction. The main line was built of 8-in. seamless line pipe in two weights—28.55-lb. and 25.06-lb.—placed as indicated in the accompanying sketch, with the exception of 24.3 mi. of 17.02-lb., 6-in. line on the western slope into Salt Lake City.

Contrary to reports elsewhere, the line was welded entirely by the stove-pipe method. Fast becoming the only method employed by leading contractors—it is significant that this is probably the first line of its size and length to be entirely stove-piped.

The line was coated over most of its length. Hot enamel wrapped with asphalt-felt was used except for a 44-mi. section on which asphalt-mastic coating was applied.

Among the most interesting pieces of equipment employed on the line were (1) the rooter and (2) the angle bulldozer. The rooter, shown in an accompanying photograph and sketch, is new to pipe-line work but well-known in highway construction. Its purpose in the pipe-line construction was to precede the ditching machines, literally rooting its way along the pipe-line route, unearthing boulders and disclosing other hidden "trouble" that might have disabled the ditcher.

The angle bulldozers did a splendid job of clearing right-of-way and of serving in so many ways to speed the construction of the line. Boulders of almost unbelievably large size were pushed out of the way with little or no trouble. An accompanying photograph gives an idea of the rocks encountered by the machines.

The speed and efficiency with which all contractors on the project executed their part of the work is truly a mark

of the progress that has been made in recent years in pipe-line construction.

Features of Station Design

The pump stations on the line were designed, built, and equipment was installed under the direct supervision of the Stanolind Pipe Line Company. Consequently, the stations reflect the judgment and experience resulting from this company's operations over the entire United States.

The station at Fort Laramie is, of course, an established station on Stanolind's line to Freeman, Missouri, and thus is not to be considered as a part of the new line.

The three stations—Medicine Bow, Wamsutter, and Granger—each consists of pumping facilities, auxiliary equipment, and housing facilities for the operators.

At each station, two pumping units are installed—one as an operating unit, the other as a standby. Each of these units comprises a 250-hp., 5-cylinder, vertical gas-Diesel engine operating at 400 r.p.m., direct-connected through a flexible coupling to a 4½-in. by 16-in. horizontal duplex double-acting reciprocating pump. Pumps and discharge piping are designed for 1500-lb. operating pressure. All piping flanges are of the ring-joint type.

An interesting feature of the engine is the 20-kw. d-c. generator, the rotor of which is an integral part of the engine shaft. Mounted thus between the outboard bearing and the flywheel, belts and pulleys are eliminated and less floor space must be provided in the engine room than when the conventional generator is installed. This generator supplies auxiliary power and lighting in the station and in the cottages.

Each engine is equipped with a Woodward governor and is to be provided soon with an auxiliary speed control for varying engine speed in accordance with the suction pressure on the pumps, thus permitting virtually automatic synchronization of pumps at all stations on the line. Pressure for operating this speed control will be obtained from the suction line by receiving the incoming stream against a pressure-regulating valve installed in the manifold and adjusted to maintain 10- to 15-lb. pressure on the pumps at all times. In addition to providing pressure for operating the governor control, this back-pressure arrangement permits better filling of the pumps with less slippage and a consequent reduction in evaporation loss from the storage tanks.

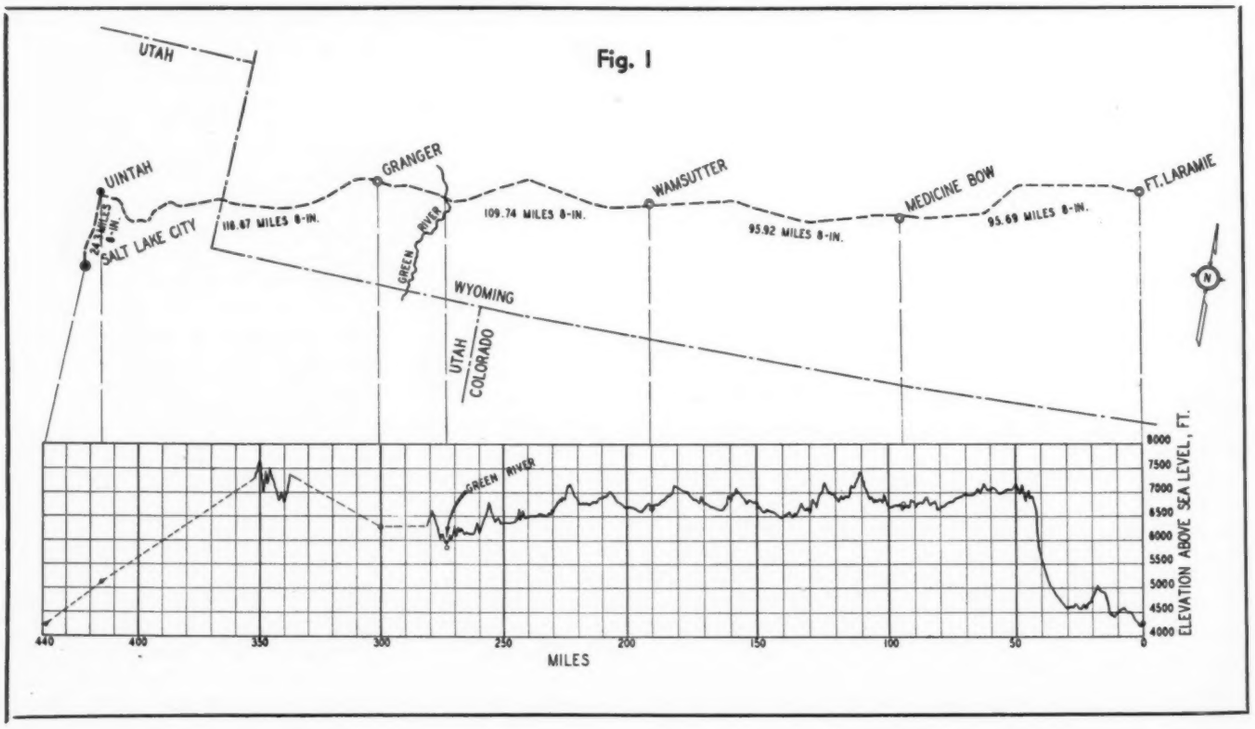
A motor-actuated valve controlled by a diaphragm-type pressure regulator is installed in the line to the tanks. The hook-up is designed so that incoming pressures higher than 10 lb. per sq. in. will cause the valve to open, permitting the oil to enter the tanks, thus maintaining no more than the desired 10-lb. suction pressure on the pumps. Likewise, if the incoming pressure becomes less than 10 lb., the valve will open, admitting oil from the storage tanks into the suction line to the pumps. A 4-in. rotary-type suction pump having a capacity of 200 bbl. per hr. is provided to assist in moving the oil from storage during cold weather or whenever its help is needed. This pump is powered by a 15-hp. d-c. motor through a motor-type gear-reduction unit. The pump may also be used in clearing the manifold lines during a shutdown.

The engines at Medicine Bow and Granger stations operate as gas engines, utilizing local gas as fuel. The engines at Wamsutter station, being remote from a gas supply, necessarily must operate as Diesels, using oil from the pipe line as fuel. The high elevations of the station sites and the consequent rarefied atmosphere result in a derating of 24 percent in engine capacity. The effects of lower atmospheric pressure can, of course, be offset by supercharging, if desired. Supercharging is not contemplated on the Utah line but the pumps will lend themselves to an increase in capacity if this method should be employed in the future.

The pumps are of the completely-enclosed, self-lubricating type. The crankshaft of the pump rotates in roller-type bearings. The pinionshaft bearings are of the babbitt-lined split-sleeve type. The latter bearing was specified rather than the roller-type so that the pump-half of the flexible coupling could be removed from the shaft whenever this is necessary.

Auxiliary equipment at each station includes a 60-hp. automotive-type

Fig. 1



radiator-cooled engine designed to operate on either natural gas or gasoline as fuel. This engine drives a 20-kw. d-c. generator as an emergency source of power and lights and for operating the motor-driven air compressor or motor-driven suction pump at times when the main units are not operating.

The air compressor is a 2-cylinder air-cooled unit connected to its motor through a V-belt drive.

The engine-water cooling system consists of a shell-and-tube type heat exchanger in which the heat of the water is imparted to the incoming oil in the pipe line. A low-head centrifugal pump, motor-driven, is installed to restore the pressure drop of the oil through the exchanger when pumping directly out of the storage tanks.

The buildings housing the pumping equipment are steel-framed, covered by pressed-asbestos siding and roof. The heating plant—a small steel boiler—is installed in a separate building and is designed to be fired by either gas or oil.

Each station has four 5-room houses and one 6-room house. At Wamsutter and Granger stations, all houses are erected on the station site. At Medicine Bow, four houses are erected in town. The chief engineer's house is situated on the station site—four miles from town.

Pressure Calculations

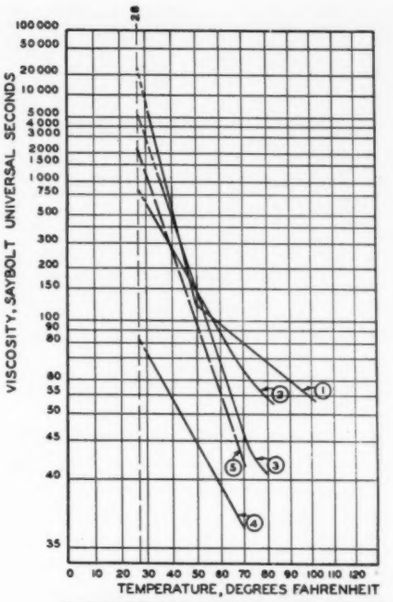
Most interesting problem in connection with the Utah line involves the ability of the line to pump oil during the extremely cold winter months. The final test must depend upon actual conditions encountered during the present winter. In lieu of this, the following calculations have been made.

General Statement of the Problem

The unknown at the present time as the Utah line is being placed into operation involves the conditions that may be encountered under winter operating temperatures. Consequently, it is extremely interesting to make a few calculations in an attempt to forecast the pressures that will be required to move the cold, sluggish oil that will be present in the line.

The problem that represents the worst anticipated conditions may be stated as follows:

Assume that Leo and Sundance (Lance Creek) crude oils are mixed in equal volumes at Fort Laramie and that 3500 bbl. per day of this mixture is to be pumped from Fort Laramie to Medicine Bow station. At Medicine Bow, the volume to be pumped will be augmented by the addition of 2500 bbl. per day of Rock Creek crude oil



VISCOSITY - TEMPERATURE CHART

CURVE NO.	TYPE OF CRUDE OIL	A.P.I. GVTY. @ 80°F.
1	LA BARGE	28.0°
2	ROCK CREEK	38.0°
3	LEO	43.4°
4	(SUNDANCE) LANCE CREEK	48.3°
5	LEO & LANCE CREEK 50-50 MIXTURE	ESTIMATED 44.9°

Fig. 2

and 800 bbl. per day of Medicine Bow crude oil. The total volume of 6800 bbl. per day is to be pumped from Medicine Bow to Wamsutter to Granger and thence to Salt Lake City.

The above is more than a hypothetical problem inasmuch as it may approximately represent winter operation of the line. The volumes pumped represent average volumes anticipated during the life of the line. During the summer months La Barge crude oil will be accepted at Granger station from the line originating at Opal. During the winter months, however, none of this extremely viscous oil will be accepted so that this element should properly be omitted from the calculations.

Viscosity and Temperature

The best information available, based upon pipe-line experience in the Rocky Mountain area, indicates that pipe-line temperatures, even under flowing conditions, may be expected to be as low as 28°F. This temperature has been assumed, therefore, in the problem.

The elements of the problem just outlined are presented graphically in the accompanying sketch, Fig. 3.

The real problem is, of course, to determine what the characteristics of the crude oil will be at a line temperature of 28°F. The accompanying viscosity-temperature curves, Fig. 2, indicate the unfavorable viscosity trend at low temperatures of certain of the crude oils, particularly the Leo and La Barge oils. On the other hand, the Lance Creek and Medicine Bow oils have relatively excellent viscosity characteristics and it is easily seen why it is desirable to mix-in as much of these oils during the winter months as possible.

The problem is complicated, too, by the inability to determine accurately the viscosities of these viscous oils in the laboratory. There is no viscosimeter available, not even the Saybolt Furol, that will permit the heavier oils to flow through the tips at temperatures comparable to those anticipated.

For this reason, it has been necessary for the designers of the line to use their best judgment in estimating the conditions that may prevail and then to await results of actual operation during the most severe period to determine the true characteristics of the oils. Incidentally, it is known that crude oil samples that will not flow through a viscosimeter tip in a quiescent state may be stirred and made to flow. This indication that agitation prevents the formation of crystals and thus enables the oil to remain somewhat liquid is valuable in that it gives some assurance that the oil may be pumped successfully if it is constantly in movement. Shutdowns, permitting the oil to come to rest, may, of course, result in "freezing" the oil beyond the ability of the pumps to move it or of the line to withstand the pressures required to regain flow. Troubles of this kind are known to have occurred in older lines in this area, and are to be avoided at all costs.

Estimated Viscosities at 28° F.

It has been necessary to extrapolate the viscosity curves of the crude oils in Fig. 2 and thus estimate the viscosities at a temperature of 28°F. Likewise, the viscosity curve for a mixture of equal volumes of Leo and Lance Creek crude oils has been averaged from the curves of these two oils as the best means available for estimating the viscosity of the mixture. The result may be far from accurate but there is no way of checking this.

Data based on the viscosities of the oils and required in the problem are tabulated in Table 1.

Determination of dvs/u and f

The first step is to determine the value of the ratio dvs/u, a dimensionless quantity sometimes termed Reynolds' number, in which d equals the diameter of the pipe, v, the velocity

TABLE 3

Section of line*	dvs/u	f
A	819	0.0800
B	810	0.0808
C	2450	0.0480
D	2420	0.0485
E	2190	0.0445

*Letters refer to similar sections as in Table 2.

of flow, s the density and u the absolute viscosity of the fluid. Determination of this value is essential in order (1) to determine whether streamline or turbulent flow conditions will exist and (2) to evaluate f, the friction coefficient, needed in the calculations in the event that turbulent flow is found to exist.

Following Heltzel's[1] method, dvs/u may be expressed in terms with which engineers are more conversant by expressing velocity in terms of bbl. per hr., and the internal diameter of the line in inches as in the following formula:

$$dvs/u = \frac{0.02381\,B}{D} \quad \frac{s}{u}$$

In the present problem involving the Utah line there are five distinct conditions each requiring, for extreme accuracy, a separate calculation of dvs/u. These varying conditions are occasioned either by a change in the volume pumped (affecting B) or a change in internal line size (affecting D). From a practical consideration, the change of wall thickness of the 8-in. line could be disregarded without serious effect but in the present study this slight variation has been included in the calculations. The data needed in calculating the dvs/u values for the five conditions are tabulated in Table 2.

[1] "Fluid Flow and Friction in Pipe Lines," by William G. Heltzel, *The Oil & Gas Journal*, June 5, 1930.

TABLE 1

Crude oil	Saybolt Universal seconds	$\frac{u^*}{s}$	$\frac{s}{u}$
50 percent Leo 50 percent Lance Creek	2250	.0053316	188
100 percent Rock Creek	800	.0018936	528
100 percent Medicine Bow	40	.0000463	21600
$\frac{3500}{6800}$ or 51.5 percent Leo-Lance Creek			
$\frac{2500}{6800}$ or 36.8 percent Rock Creek	1458	.0034541	290
$\frac{800}{6800}$ or 11.7 percent Medicine Bow			

$$\frac{^*u}{s} = .00000237 - \frac{0.00194}{t}$$

in which: $\frac{u}{s}$ = kinematic viscosity in English units

t = time of efflux, Saybolt Universal seconds.

Reference to a chart showing Stanton and Pannell's experimental data correlating values of f and dvs/u shows that flow in the section of line from Fort Laramie to Medicine Bow will be streamline or viscous; from Medicine Bow to Salt Lake City turbulent flow conditions will exist. For those who do not readily recall Stanton and Pannell's work, it may be well to point out that dvs/u values of 1000 and less are classed in the streamline region; values from 1000 to 2500 are in the so-called critical or transitional zone, in which neither streamline or turbulent flow are pronounced, and values of 2500 and higher are in the turbulent region.

As Heltzel[1] points out, where the value of the ratio dvs/u falls in the transitional zone, it is believed advisable to obtain the value of f from the dotted curve (the turbulent flow curve) for dvs/u values between 1500 and 2500 rather than from the lower part of the streamline flow curve. This precaution will give reasonable assurance that the pipe line as designed will be adequate for the work expected of it.

From the curves referred to above, the values of f determined for the various dvs/u values are listed in Table 3.

Pressure Drop and Horsepower Requirements

Fort Laramie-Medicine Bow. It has been determined that viscous flow will prevail in this section of the line under the conditions assumed. Viscous flow is not ordinarily assumed to be efficient flow for reasons that are apparent from a thorough study of the flow formulas. It is apparent, however, that either an increase in the volume pumped from Fort Laramie, a decrease in the viscosity of the fluid, or both could easily result in turbulent flow conditions.

Pressure drop when streamline flow exists may be calculated from the following formula:

$$P = 1500\frac{Bu}{D^4} \text{ lb. per sq. in. per mi...} (1)$$

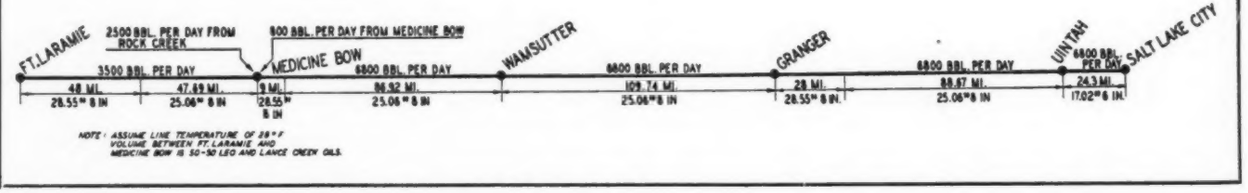
To evaluate u, the absolute viscosity of the oil pumped in this section of line, it is necessary to determine its density, s, so that u may be calculated from the s/u values already determined.

An average of the gravities of Leo and Lance Creek crude oils indicates a 50-50 mixture would have a gravity of approximately 45° A.P.I. The specific gravity of the mixture would be:

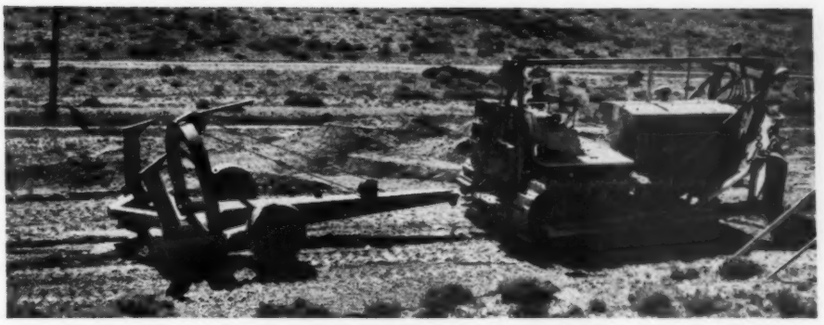
TABLE 2. Values of dvs/u — Utah Line

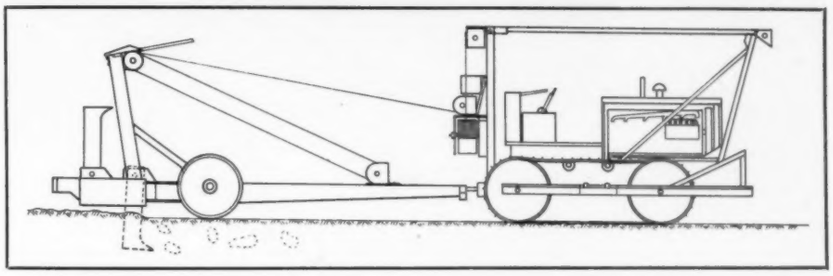
Section of line	Line size		Volume pumped, bbl.		s/u	dvs/u
	Weight, lb. per ft.	I.D., in. (D)	per day	per hr. (B)		
(A) Fort Laramie-Medicine Bow	28.55	7.981	3500	146	188	819
(B) Fort Laramie-Medicine Bow	25.06	8.063	3500	146	188	810
(C) Medicine Bow-Uintah	28.55	7.981	6800	283	290	2450
(D) Medicine Bow-Uintah	25.06	8.063	6800	283	290	2420
(E) Uintah-Salt Lake City	17.02	6.125	6800	283	290	3190

Fig. 3



Photograph and sketch of rooter used in advance of ditching machine





$$\frac{141.5}{131.5 + 45} \text{ or } 0.802$$

The density, s, in lb. per cu. ft. would be:

$$62.4 \times 0.802 \text{ or } 50$$

From Table 1, u/s for the oil in sections A and B is 0.0053316. The value of u is, therefore,

$$0.0053316 \times 50 = 0.2666$$

Knowing all the values needed in equation (1), the pressure drop, P, may be calculated.

In the 28.55-lb., 8-in. line,

$$P = 1500 \times \frac{146 \times 0.2666}{7.981^4}$$

$$= 1500 \times \frac{38.92}{4057}$$

$$= 1500 \times 0.00959$$

$$= 14.4 \text{ lb. per sq. in. per mile}$$

In the 25.06-lb., 8-in. line,

$$P = 1500 \times \frac{38.92}{8.063^4}$$

$$= 1500 \times \frac{38.92}{4227}$$

$$= 1500 \times 0.00921$$

$$= 13.8 \text{ lb. per sq. in. per mile}$$

From the profile of the line in Fig. 1 it is noted that at a point approximately 49 mi. west of Fort Laramie station, the elevation is 7260 ft. The pressure required to lift oil to this point may be determined as follows:

$$48 \times 14.4 + 1 \times 13.8 + 0.433 \times 0.802 \ (7260\text{-}4230)$$

$$= 691.2 + 13.8 + 0.347 \times 3030$$

$$= 1756 \text{ lb. per sq. in.}$$

Analyzing this figure, it is evident that only 705 lb. per sq. in. is required to overcome the pressure drop due to friction but 1051 lb. per sq. in. is the pressure required to offset the hydrostatic head of the oil in the line.

In the rest of the line into Medicine Bow station, the total pressure drop is:

$$46.69 \times 13.8 + 0.347 \ (6700\text{-}7260)$$

$$= 644 - 194 = 450 \text{ lb. per sq. in.}$$

Consequently, although the difference in elevation aids rather than hinders the movement of the oil, it is not enough to offset the pressure drop due to friction.

The total pressure required at the discharge of Fort Laramie station, including allowance for a delivery pressure of 10 lb. per sq. in. at Medicine Bow station, is:

$$1756 + 450 + 10 = 2216 \text{ lb. per sq. in.}$$

Inasmuch as the stations are designed for a maximum working pressure of 1500 lb. per sq. in., the above figures indicate that, should line temperatures approaching 28°F. be experienced, the volume of the oil pumped would have to be curtailed until higher temperatures prevailed. This would be necessary probably for only a short period, if at all, during the height of an extended cold winter.

If a maximum pressure of 1500 lb. per sq. in. at Fort Laramie is used as the limiting condition, the volume that can be pumped may be determined as follows:

The hydrostatic head remaining the same, the total pressure available to offset friction is:

$$1500 - 1051 + 194 = 643 \text{ lb. per sq. in.}$$

As B is the quantity to be found, the following equation may be set up to aid in its determination:

$$48 \times 1500 \times \frac{0.2666\ B}{4057} + 47.69 \times 1500 \times \frac{0.2666\ B}{4227} + 10 = 643$$

$$72000 \times \frac{0.2666\ B}{4057} + 71535 \times \frac{0.2666\ B}{4227} + 10 = 643$$

$$\frac{19195\ B}{4057} + \frac{19071\ B}{4227} + 10 = 643$$

$$4.73\ B + 4.51\ B = 643 - 10$$

$$9.24\ B = 633$$

$$B = 68.5 \text{ bbl. per hr.}$$

$$68.5 \times 24 = 1644 \text{ bbl. per day}$$

Consequently, by reducing the volume pumped from Fort Laramie station to 1644 bbl. per day, it is possible that a line temperature of 28°F. may be experienced without exceeding a discharge pressure of 1500 lb. per sq. in.

Medicine Bow-Uintah. Having considered the possibilities of the more critical eastern section of the line in which viscous-flow conditions prevail, it will be of interest to consider the sections of the line in which turbulent-flow conditions exist.

The formula for pressure drop under turbulent flow conditions may be expressed as follows:

$$P = 0.55830\ f \frac{B^2 s}{D^5}$$

In the 28.55-lb., 8-in. line,

$$P = 0.55830 \times 0.0480 \times \frac{290^2 \times 50}{7.981^5}$$

$$= 0.02680 \times \frac{4{,}205{,}000}{32{,}380}$$

$$= 0.02680 \times 129.9$$

$$= 3.48 \text{ lb. per sq. in. per mile.}$$

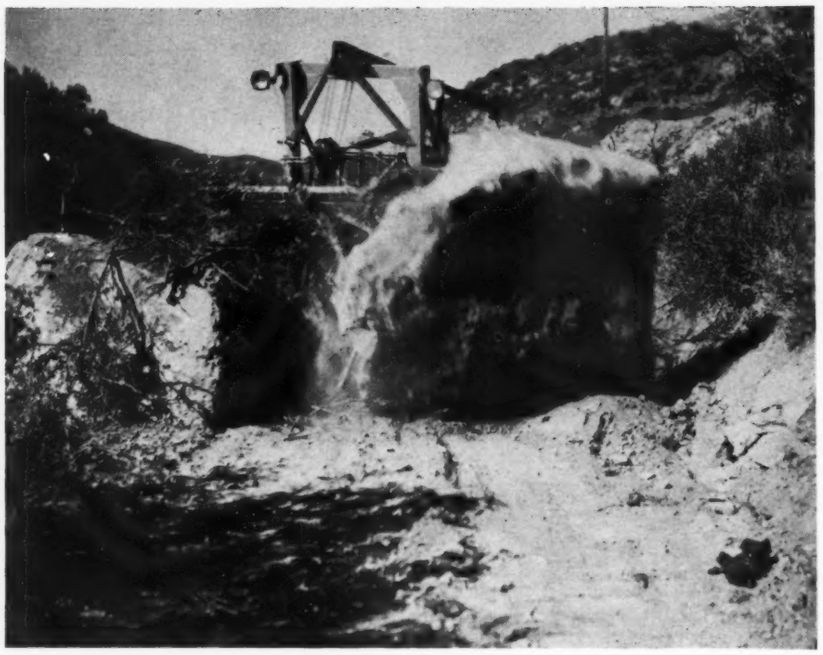
In the 25.06-lb., 8-in. line,

$$P = 0.55830 \times 0.0485 \times \frac{4{,}205{,}000}{8.063^5}$$

$$= 0.02708 \times \frac{4{,}205{,}000}{34{,}080}$$

$$= 0.02708 \times 123.4$$

$$= 3.34 \text{ lb. per sq. in. per mile.}$$



Boulders so large they virtually hide the operator are moved easily by angle bulldozers in clearing right-of-way

Having determined the unit pressure drops in the two sizes of line involved, the total pressures required at Medicine Bow, Wamsutter, and Granger stations may be calculated.

The total pressure required between Medicine Bow station and the peak noted on the profile approximately 17 mi. from Medicine Bow is:

$9 \times 3.48 + 8 \times 3.34 + 0.347$ (7340-6700) $= 31.3 + 26.7 + 222 = 280$ lb. per sq. in.

From the peak to Wamsutter station, the total pressure required is:

$78.92 \times 3.34 + 0.347$ (6800-7340) $= 263.6 - 187.4 = 76.2$ or 76 lb. per sq. in.

If Wamsutter station is operating and it is desired to deliver to the pumps or into the tanks at 10 lb. per sq. in., total pressure required at the discharge of Medicine Bow station will be:

$280 + 76 + 10 = 366$ lb. per sq. in.

Pressure required between Wamsutter and Granger stations, disregarding the intermediate point of higher elevation is:

$109.74 \times 3.34 + 0.347$ (6275-6800) $= 366.5 - 182.2 = 184.3$ or 184 lb. per sq. in.

If Wamsutter station is bypassed, Medicine Bow can deliver into Granger by discharging at a pressure of $366 + 184 = 550$ lb. per sq. in.

Between Granger station and the peak elevation west of Granger, the pressure required is:

$28 \times 3.48 + 20 \times 3.34 + 0.347$ (7660—6275)

$= 97.4 + 66.8 + 480.6$

$= 644.8$ or 645 lb. per sq. in.

Between the peak and Uintah junction, assuming a uniform drop in elevation to Salt Lake City (in the absence of detailed profile) the pressure drop is:

$68.67 \times 3.34 + 0.347$ (5120-7660) $= 229.4 - 881.4 = -652$ lb. per sq. in.

It is apparent from these figures that the only work required of Granger station is in pumping to the peak. The drop in elevation west of the peak supplies enough pressure by gravity to overcome the friction in the line to Uintah.

Pressure drop in the 6-in. line south of Uintah is:

$$P = 0.55830 \times 0.0445 \times \frac{4{,}205{,}000}{6.125^5}$$

$$= 0.02484 \times \frac{4{,}205{,}000}{8621}$$

$$= 0.02484 \times 487.8$$

$= 12.12$ lb. per sq. in.

Total pressure drop from Uintah to Salt Lake City is:

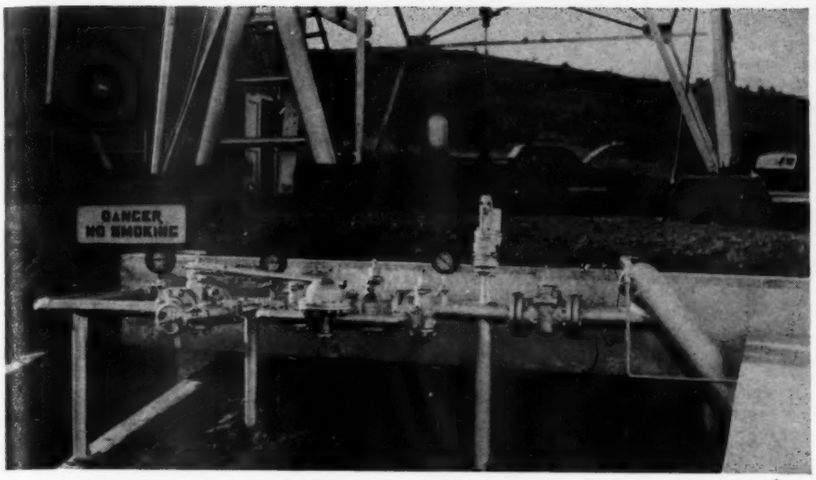
$24.3 \times 12.12 + 0.347$ (4220-5120) $= 294.5 - 312.3 = -17.8$ or -18 lb. per sq. in.

Conclusion

Assuming the lowest line temperature to be expected during winter operation (28°F.), the pressure calculations indicate that 3500 bbl. per day of a mixture of equal volumes of Leo and Lance Creek crude oils may be pumped only if Fort Laramie station is capable of developing a pressure of 2216 lb. per sq. in. If Fort Laramie is limited to a discharge pressure of 1500 lb. per sq. in., 1644 bbl. per day may be pumped satisfactorily.

Calculations based on the rest of line indicate ample capacity to pump the designated volumes.

Preparing to lower-in 8-in. line across mountain stream



Pressure-reduction equipment installed at gas well in southern Montana. Gas enters at the left, passes through flow bean and pressure regulator, past the safety valve and temperature controller, to the pipe line at right

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

Heating and Dehydrating Natural Gas at the Wellhead

Pressure reduction at wellhead in Montana gas fields necessitates adequate treatment to avoid hydrate formation

By J. E. MOORE
Vice-President and General Manager, Billings Gas Company, Billings, Montana

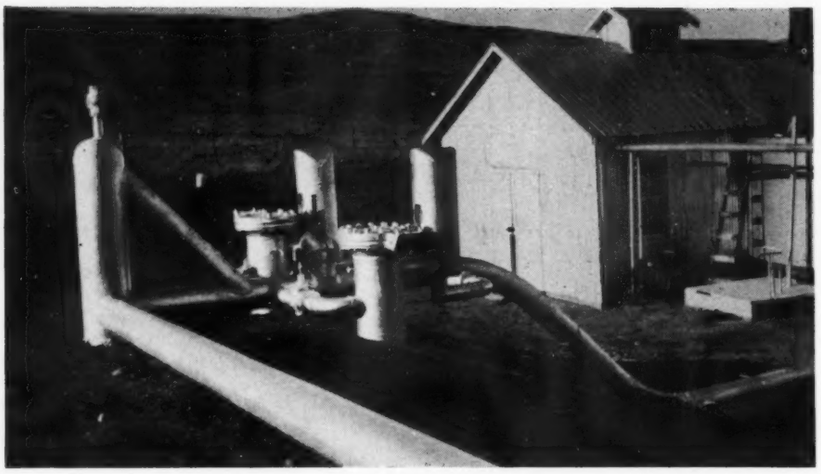
IN Montana and other northwestern states, where well pressures are high and temperatures are low, the natural gas operator encounters problems that, though common in other gas producing areas, are intensified by the severe climatic conditions under which operations are conducted. Because entire communities are entirely dependent upon gas for heat and because even brief interruptions of the gas supply would entail much suffering and inconvenience, the operator in this territory must know that the solutions found for these problems are correct in principle and dependable in practice.

In Montana and Wyoming, the two major gas-producing states of the Northwest, gas is produced at elevations of 4000 to 8000 ft. above sea level. Well pressures range upward to approximately 2500 lb. per sq. in. and winter temperatures sometime drop to minus 50°F. With gas so widely used for heating, and with the extreme range in temperatures, peak hour gas loads run as high as 25 times the minimum summer loads. Such conditions call for a certain amount of ingenuity and some departures from the orthodox practices of milder climates if dependable service is to be maintained by only a reasonable investment in control facilities.

It is a well known fact that the refrigerating effect of expanding natural gas to greatly reduced pressures reduces the temperature of the gas and of the control equipment far below that of the incoming gas. If trouble from freeze-ups is to be avoided the temperature of the gas entering the pressure-reducing apparatus must be increased sufficiently to offset this refrigerating effect and maintain the temperature of the gas on the delivery side above the point at which hydrates will form. The temperature at which hydrates are formed is considerably greater than that of the ground and pipe line in the winter time, and unless the gas is cooled again before entering the pipe line and the condensate removed in a dehydrating apparatus, trouble from hydrates will be encountered in the pipe line after the gas has cooled to the pipe line temperature, which may be as low as 10°F. in the area being discussed.

To avoid the hazards of carrying extremely high pressures in the field gathering lines, it has become a common practice in the high-pressure fields of this area to reduce the gas pressure at the wellhead. The resulting need for application of heat in close proximity to the wells has ruled out the former practice of using open-fire

J. E. MOORE
for 18 years has been in the employ of various gas companies affiliated with The Ohio Oil Company—He spent six months in the natural gasoline department of The Ohio Oil Company, for three years was local manager of The Rocky Mountain Gas Company in Wyoming, having added duties in care of field gas measurement and pressure-control equipment in Big Horn Basin fields, for four years was superintendent of distribution for the Billings Gas Company, superintendent of pipe lines for Gallatin Natural Gas Company, and from 1929 to 1933 was manager of the Billings Gas Company and superintendent of the Gallatin Natural Gas Company — Since 1933 he has been vice-president and general manager of the consolidated companies.



"Cooler line" in foreground, condensate trap at right, and brine contactors in center

heaters and has led to the development of safer and more efficient heating methods; methods that are more consistent with the principle of conservation of gas reserves.

Because of their inherent safety and the ease with which they can be closely controlled, hot water and low-pressure steam have been adopted as heating media, employing a system of gas-fired boilers, heat exchangers, flow lines, and automatic temperature-control devices in their application. Each type of heating has its own peculiar advantages and the choice between hot water and steam will depend on the circumstances involved. Steam is more quickly responsive to changing conditions of gas flow, but hot water provides a more even temperature under conditions of uniform flow. Steam systems that drain dry to the boiler when not in use are better for intermittent service; and because slightly smaller heat exchangers and flow lines can be used with steam, resulting in a consequent reduction in the installation cost, the tendency has been toward the use of steam-heating equipment. The application is much the same in either case, the principal difference being in the arrangement of the flow lines and in the type of control equipment.

To meet climatic conditions, many early installations were made partly or entirely underground, having separate and sometimes quite elaborate buildings for boilers, regulators, and meters and the necessary connecting piping underground. The many hazards involved, however, in such installations, the inconvenience and difficulties encountered in maintenance, and the high cost of subsurface buildings have led to the gradual evolution of a much simpler, safer, and less expensive, though equally effective, type of installation. All equipment has been brought aboveground and the adoption of new and improved control devices and better application of older types of equipment have resulted in an extremely compact and efficient control unit.

A well hook-up recently completed in the Dry Creek field in southern Montana is an example of simplified control incorporating the several features mentioned. This well has a shut-in pressure of 1700 lb. and has been equipped to deliver as much as 10,000,000 cu. ft. per day under exact control of delivery pressure at all rates of delivery to less than 250,000 cu. ft. per day. Pressure is reduced in one stage to 300 lb. at the well for delivery into the pipe line operating at that pressure.

Provision is made for limiting the amount of gas taken by the use of a flow bean. Both the flow bean and the pressure regulator may be bypassed when necessary to facilitate servicing or to permit delivery of gas beyond the capacities of those devices. Heat is automatically controlled by means of a direct-acting steam-flow control valve actuated by a temperature-sensitive bulb installed in the gas line on the delivery side of the pressure regulator. A safety valve guards against possible excessive pressure. All the functions of a field regulator station are provided for, and in an overall area of approximately 4 ft. by 10 ft. The entire assembly is outdoors and has no protection other than a good coat of paint.

The heat exchanger is installed between the wellhead and the pressure-regulating equipment. It was fabricated on the job by splitting a 4-in. pipe longitudinally into four sections and welding-in sides of steel plate to form a box having rounded corners and a length of 24 ft. The ends were closed by welding-in steel plates after the inside gas piping had been inserted. This gas piping consists of a single 3-in. extra heavy pipe entering and leaving the box through the centers of the end plates, but branched inside the box to provide five 3-in. lines having a total length of 110 ft. A section of large pipe or casing would have served equally well for the outer casing, or steam chamber, and has been used on many jobs.

Steam is supplied to the steam chamber by a steam pipe extending through the full length of the steam box, with an opening in the pipe near the end farthest from the boiler where the steam pipe is blanked off. Another opening is made on the other side of the blank plate and a safety valve is installed on the end where the steam pipe extends through the end of the steam box. This is to take care of the possibility of gas leaks in the gas piping inside the box building-up dangerous pressure or allowing gas to reach the boiler through the steam flow lines. The entire assembly slopes slightly toward the boiler, the condensation return line leading from the low end.

In this particular installation the heat exchanger is situated in the runway to the well cellar. In most cases, however, it is placed farther from the well and is adequately insulated and then cased by a galvanized-iron jacket. Steam flow line, condensation return line, and fuel line for the boiler are enclosed in a wooden box packed with rock wool and covered by galvanized iron. All lines slope to the boiler at a pitch of not less than ¼ in. per ft. When the boiler must be situated on flat ground at the same level as the wellhead, the heat exchanger is elevated to provide the required slope.

After the gas leaves the control equipment, it is carried some 250 ft. through a section of large pipe placed aboveground in which the gas is exposed to atmospheric temperature, usually much lower than ground temperature in winter. Condensates are trapped at the end of this "cooler line" and the gas is then passed through calcium chloride brine contactors, prior to entering the pipe line. These contactors are bypassed except when ground temperatures are lower than that at which hydrates form at existing pipe-line pressure.

Drilling and Completion of 10,000-Foot Well in Louisiana Gulf Coast

Drilling of LLE-2 Paradis, St. Charles Parish, to total depth of 11,169 ft. and plugging-back to complete at 10,348 ft., characterized by lack of difficulties—area may prove to be one of best fields in South Louisiana

By H. LEE FLOOD
Associate Editor

THE most important discovery of the year on the Gulf Coast of Louisiana is the very recently completed well drilled by The Texas Company in St. Charles Parish near the town of Paradis, approximately 31 mi. northeast of Houma and 14 mi. southwest of New Orleans.

The well, LLE-2 Paradis, is the second well drilled on the structure by The Texas Company and consequently is not a wildcat in the usual sense of the term. The first well, however, the LLE-1 Paradis, completed in June, was drilled-in to what is now believed to be the gas cap of the structure and produced only gas and some condensate from sand at depths of 9900-9920 ft. The second well, located apparently on the flank of the structure, drilled through a fairly thick section of gas and condensate formation but drilled deeper to discover one of the thickest and what may prove to be one of the most prolific oil reservoirs discovered recently in southern Louisiana. A total of 140 ft. of oil-saturated sand was logged in the well, of which only 45 ft. is being produced through perforations in the casing. Potential of the well is 1710 bbl. per day through ⅜-in. choke. Pressure on the tubinghead is 1750 lb. per sq. in. A test of potential by the Louisiana Department of Conservation showed 1852 bbl. per day through a ¼-in. choke.

Drilling History

LLE-2 Paradis was spudded-in on September 3, 1939. The well was drilled, logged, cased, completed, tested, and production was flowing into the tanks on November 28—87 days total time. Much of this time was occupied in coring and logging the well. As additional wells are drilled and more is known of the structure, total time to complete a well will probably average two months, of which probably 30 days will be required for actual drilling.

First job was to set a temporary 100-ft. string of 15-in. casing as a conductor pipe. Following this, 13⅜-in. hole was drilled to permit setting a permanent surface string of 54.50-lb., 10¾-in. lap-welded casing bottomed at a depth of 1927 ft. and cemented by 300 sacks of cement.

After the cement had set, the plug was drilled and drilling continued. A 9⅞-in. hole was carried to 10,491 ft., at which depth a 7-in. casing string was cemented, using a whirler shoe and two float joints. Two weights of 7-in. were used—26-lb. and 28-lb.—of the external-upset type employing a two-stepped thread for rapid coupling while being run-in the hole. In cementing the 7-in. casing string, 1000 sacks of cement were used to fill the space between the open hole and the casing an estimated depth of 3000 ft.

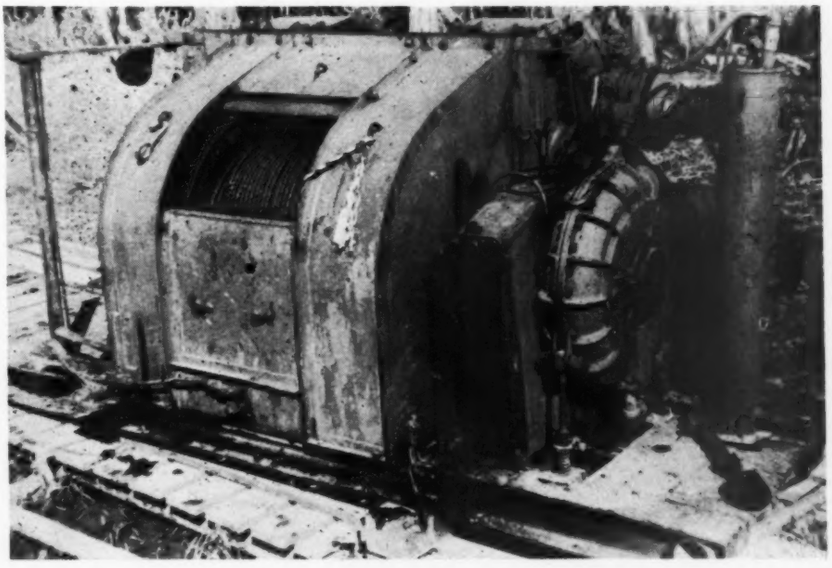
After the cement plug in the 7-in. string had been drilled-out, the hole was deepened. Being the initial test of these depths in the structure, probably greater attention was devoted to coring and electrical logging than would be considered necessary in wells drilled hereafter on the structure. Consequently, considerable elapsed time was required in order to attain the total depth of 11,169 ft.

As a step preparatory to completing the well, a 792-ft. liner of 18-lb., 5-in. external-upset casing having two-stepped threaded joints was placed in the hole and cemented by 150 sacks of cement. Seated at a depth of 11,144 (25 ft. off bottom) the liner extended into the 7-in. casing 139 ft.

Several promising productive formations were logged in the lower depths of the well but it was finally decided to place a cement plug at the top of the 5-in. liner using a cement retainer and 50-sack batch for the job. Effective total depth of the well following the plug-back was 10,348 ft.

Selected as the best portion of the oil-saturated section, the 7-in. casing opposite the upper oil sands at depths of 10,295 to 10,340 ft. were gun-perforated. The 45-ft. section was "double-perforated", i.e., twice as many shots were employed, resulting in four shots per ft. of depth, a total of 180 perforations in all.

After cleaning itself, the well showed evidence of being a large pro-



Drawworks used in drilling the well, ready to be moved to the next job

ducer and steps were taken to prepare the well for production.

During drilling, the well was protected by the use of a blowout preventer having pipe rams, above which another blowout preventer having blind rams was installed. Both preventers were hydraulically-operated. The top valve was a manually-controlled drilling head equipped with pipe rams. All valves were 6000-lb. test.

After the drilling controls were removed, a string of 2½-in. external-upset tubing was run-in the well. Following the practice adopted for southern Louisiana wells, a double-packer was installed in the tubing string above the screen. Usual practice is to set the packers 60-100 ft. above the producing zone. Slotted or wire-wrapped screens are used, depending upon the amount of trouble encountered with sand.

Installed in the tubing string 400 ft. below the surface is a removable bottom-hole adjustable choke, adopted as standard equipment on most Gulf Coast wells, particularly those in marine locations. The purpose of the choke is to safeguard against damage from hurricanes and other storms that might wreck the surface connections. In the event a break of any kind causes a loss of pressure, the abnormally high differential across the choke effectively closes the choke and automatically closes the well, preventing a loss of control. Locally the devices are termed "storm" chokes, an appropriate name considering the purpose for which they are intended.

At the surface, the 2½-in. tubing is swaged to a 3-in. heavy steel hanger nipple suspended in a tubinghead on which the Christmas-tree assembly is mounted.

Tubing pressure is reduced and flow controlled through an adjustable flow choke installed in the surface piping. Pressure is reduced in one stage from 1750 to 35 lb., preparatory to entering the oil-gas separator. The separator and two 1000-bbl. flow tanks are mounted on a wooden platform adjacent to the well. Initial tests indicate a satisfactory gas-oil ratio of 856 cu. ft. per bbl. No water is being produced and it is not anticipated that water will be an immediate problem.

Drilling Equipment

The drilling contractor, Dixie Drilling Company, employed a steam-powered rig in drilling the LLE-2 Paradis.

The drawworks had 9-in. shafts and

Tubinghead assembly below the derrick floor

was driven by a 14-in. by 14-in. steam engine.

Two 20-in. mud pumps were used. A 4½-in. drill-pipe string was used in drilling the well. Rock bits were used, predominantly three-cone, but some two-cone bits were employed to drill through the softer formations encountered.

Four 125-hp. boilers were used in the earlier part of the drilling, fired by a popular type of burner utilizing gas as fuel obtained from the discovery well. The boilers generated and delivered steam for drilling operations at a pressure of 350 lb. per sq. in. Two 10-in. by 4½-in. by 10-in. duplex pumps were used to pump boiler feedwater from a nearby bayou.

After the 7-in. casing was set, two of the boilers were taken out of service. Contrary to the belief of many, deeper drilling requires less steam instead of more because the greater depth contributes sufficient hydrostatic head in the mud column to reduce materially the pump pressures required.

General

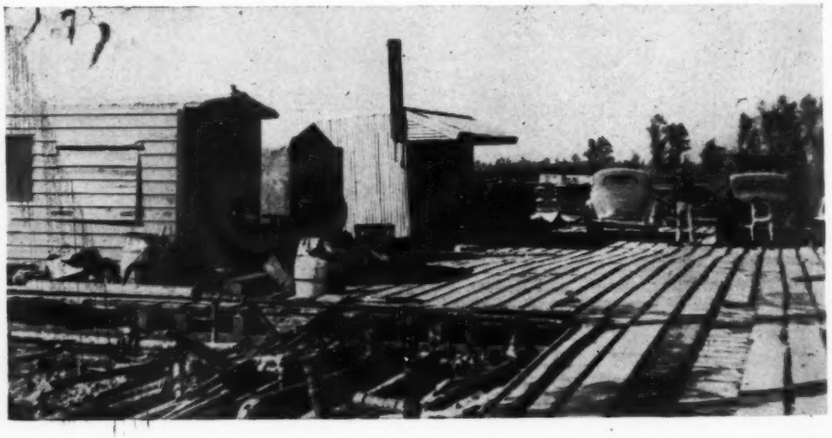
The lack of trouble encountered in drilling LLE-2 Paradis is a tribute to the experience and ability of the contractor, drilling crew, and the company's personnel.

Much of the success should be credited to the competent mud control maintained throughout the drilling operation. The Texas Company assigned a mud engineer to the job, a practice that is recognized as sound in any deep-drilling project, particularly on the Gulf Coast. Operators in southern Louisiana are more convinced than ever that attention to mud control can spell success or failure more decisively than can any other single factor.

It is too soon to determine the exact nature or extent of the new Paradis reservoir. Two wells can provide little data except for speculative purposes. Contrary to early reports, it is now believed that, rather than being adjacent to a salt dome, the new field is situated over a structural dome, the exact nature of which is not yet known. Information pertaining to the characteristics of the sand can not be disclosed at this time.

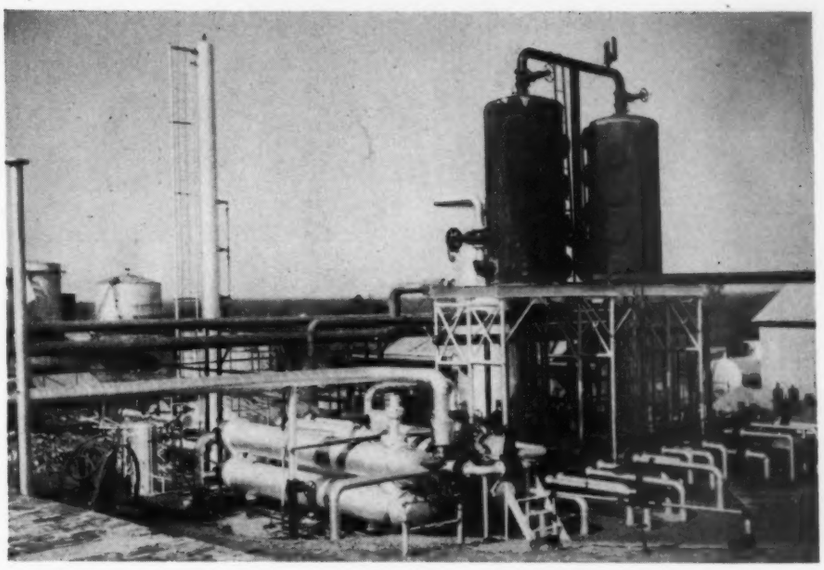
LLE-1 Paradis is located 11,723 ft. south and 7709 ft. east of the northwest corner of T 14s R20e. LLE-2 Paradis is located 660 ft. west and 660 ft. north of C NW 8-14s-20e. LLE-3 Paradis, 660 ft. south and 660 ft. east of C NW 8-14s-20e, is being prepared for drilling, to start as soon as the lateral board road and the mud sills are installed.

The field is situated in a swampy area requiring board roads as a means of access to the wells. Some 6900 ft. of board road was required to reach LLE-2 Paradis.



Storage and tool sheds at LLE-2 Paradis. Note board road construction required in this swampy area

Distillation area; stabilizer is shown to the left in background



A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
FRANK H. LOVE
Managing Editor

New Gasoline Plant in Shreveport Field, Louisiana, Has Capacity of 25,000,000 Cubic Feet Gas

Absorption-type unit taking casinghead gas from 32 of field's 49 wells—A 26-lb., 77-octane gasoline being manufactured

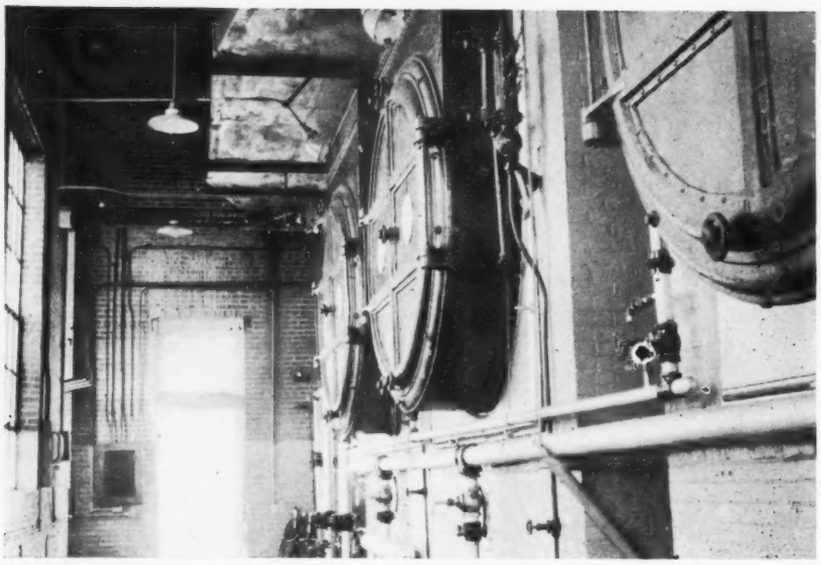
ARKANSAS Fuel Oil Company's new natural gasoline plant, erected on the site of the old Louisiana Oil Refining Company's refinery at Gas Center, Shreveport field, Louisiana, is equipped to process 25,000,000 cu. ft. of casinghead gas per day. At the present time the throughput is 16,500,000 cu. ft. per day, gas being taken from 32 of the field's total of 49 wells. The gasoline yield of the gas averages 450 gal. per million cu. ft. The plant is of the absorption type and 26-lb., 77-octane gasoline is being manufactured.

Gas is received at the plant through two gathering systems, a low-pressure and a high-pressure system. Although both systems are actually within the general classification of low pressure, being 35 lb. and 60 lb., respectively, the latter is distinguished from the former by referring to it as the "high-pressure" system. The low-pressure system, consisting of an 8-in. line having 4-in. laterals, serves ten wells. Gas is brought to the plant at a pressure of 35 lb. and passes through an inlet scrubber, 4 ft. by 10½ ft., before entering the 5-ft. by 32-ft. absorber. The low-pressure gas leaves the latter to enter a 6-ft. by 10¾-ft. outlet scrubber. After being metered, a part of this residue gas is used for fuel and instrument gas. Incidentally, one feature of the plant is the method employed to assure a supply of dry gas to the instruments. The low-pressure residue gas is passed through a charcoal absorber 4 in. in diameter by 3 ft. long, around which is fitted a 6-in. diameter jacket approximately 30 in. long; steam is injected into the annular space. There are two of the charcoal absorbers connected in parallel, only one being used at a time. When the charcoal in one absorber becomes saturated with moisture or oil it is removed from service and while it is being cleaned and dried by passing steam through the jacket, the alternate unit is employed.

The "high-pressure" gathering system is composed of 6-, 8-, and 12-in. pipe, the 6-in. having 4-in. laterals. The high-pressure gas flowing to the 6-ft. by 20½-ft. inlet scrubber at a pressure of 60 lb. is discharged to a 7½-ft. by 40-ft. absorber, thence to a 4-ft. by 8¾-ft. outlet scrubber. A part of the high-pressure residue gas is returned to the field through a 4-in. line for use in lease operations and other field developments; a portion of the residue gas is delivered into the city gas mains for domestic and industrial consumption.

Rich oil is trapped from the absorbers to a 5-ft. by 16-ft. surge tank upon which is carried a back pressure of 15 lb. The fluid level in the tank is controlled by a pilot-operated, automatic liquid-level controller. From this tank the rich oil is picked-up by a turbine-driven centrifugal pump having a capacity of 280 gal. per min. A similar pump is provided as a standby. The oil is pumped through a bank of four 20-ft., 10-in. heat exchangers, entering at a temperature of 75°F. and leaving at a temperature of 310°F. From the heat exchangers the oil passes to a direct-fired preheater, from which it enters the still at a temperature of 365°F. A second unit serves as a standby.

The still is composed of three parts, a 5-ft. diameter by 18-ft. high evaporator section having 11 plates, and two 5-ft. by 13-ft. reflux sections having 8 plates each. The latter are connected in parallel, only one reflux section being used at the present time, although



Plant steam is provided by three 250-hp. boilers operating at 100-lb. pressure

the other is expected to be placed in operation soon to give added capacity. The still is operated at 37-lb. pressure at a bottom temperature of 340°F. Gasoline vapor from the reflux section passes to three 20-ft. atmospheric-type condensers situated in the base of the cooling tower. The condensed gasoline flows into the raw gasoline accumulator, which is 6¼ ft. by 24¼ ft., and upon which pressure is maintained by a pilot-operated, back-pressure regulator. The gasoline is picked-up from this accumulator by an 8-in. by 4-in. by 12-in. steam-driven simplex close-clearance pump and charged to the stabilizer. The raw gasoline is heated in an exchanger by the hot stable gasoline from the reboiler, after which the raw gasoline enters the stabilizer tower, which is 2 ft. in diameter and 60 ft. high. The reboiler operates at a temperature of 239°F. and a pressure of 170 lb. in obtaining the 26-lb. gasoline now being produced. The reflux pump serving the tower is a 6-in. by 4-in. by 12-in. simplex close-clearance unit. After leaving the reboiler, the stable gasoline flows through heat exchangers, cooler, and into the stock tanks. There are two of the latter having a total capacity of 18,000 gal. From these two tanks the gasoline is loaded into tank cars by means of a 9-in. by 5¼-in. by 12-in. duplex pump. A two-car loading rack is provided.

After the rich oil has been stripped of its gasoline content in the still, the lean oil is pumped through a bank of heat exchangers to reduce the temperature to 175°F., then through three 20-ft. atmospheric-type oil coolers situated in the base of the cooling tower. Upon leaving the latter at a temperature of 75°F., the oil passes to a 6¼-ft. by 25-ft. surge tank. It is from this tank that the lean oil is pumped to both the low-pressure and high-pressure absorbers. For this purpose three reciprocating pumps are utilized. A 10-in. by 8½-in. by 12-in. duplex pump is used to pump the lean oil to the high-pressure absorber, a 10-in. by 5⅞-in. by 12-in. duplex pump supplies oil to the low-pressure absorber, and a 10-in. by 6-in. by 12-in. duplex unit serves as a standby for the other two.

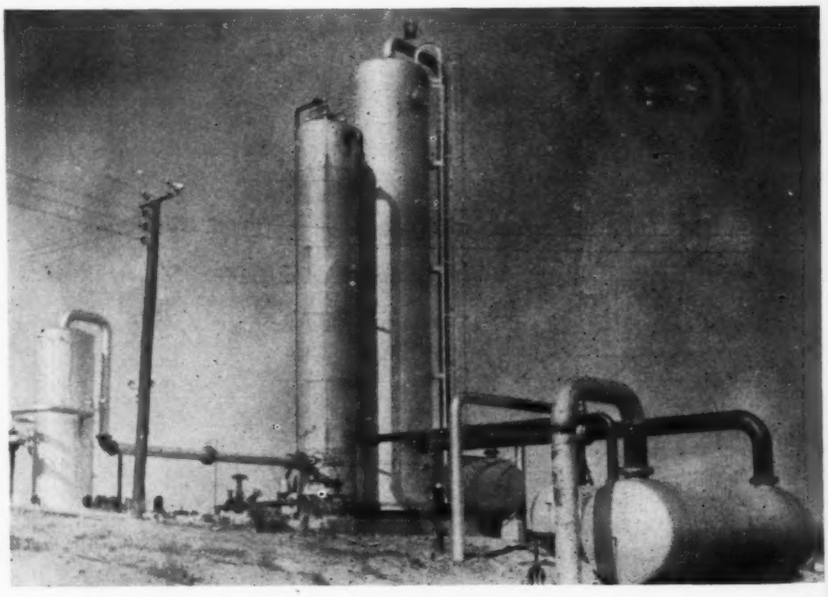
The gasoline plant is situated on the shore of Cross Lake from which water for cooling and boiler feed is taken. Cross Lake is the source of the municipal water supply for the city of Shreveport. Raw water from the lake can be pumped either directly to the cooling tower basin or to the 30-ft. diameter by 10-ft. deep round, brick-lined pond. A 10-in. by 6-in. by 12-in. duplex pump situated near the lake is utilized for this purpose. When pumped to the pond, the water is picked-up from there as needed and pumped to the basin of the cooling tower. The pump performing this work is also a 10-in. by 6-in. by 12-in. duplex unit. Overflow from the cooling tower basin gravitates back to the pond. The water, incidentally, requires no treating.

The cooling tower has 7 bays and measures 50 ft. long by 17 ft. wide by 50 ft. high. Water to the stabilizer reflux condenser and cooler is supplied by gravity, a departure from the conventional practice of pumping.

Plant steam is provided by three 250-hp. horizontal-return tubular-type boilers operating at 100-lb. pressure.

Electrical energy for the plant is supplied by a 20-kw., a-c. generator driven by a steam turbine situated in the boiler house.

Now being installed is a 2-stage compressor driven by a 110-hp. engine to recycle vapors from the gasoline accumulator, loading rack, and stock tanks—gases that now are being burned in the flare. The low-pressure cylinder of the compressor is 14 in. by 14 in. and the high-pressure cylinder is 7 in. by 14 in. The vapors will be compressed to a pressure of 150 lb. and passed through a water-cooled condenser to an accumulator from which the condensate will be trapped to the raw gasoline accumulator to be stabilized.



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Catalytic Air-Oxidation of Hydrocarbons

Oxygen of air acts as catalyst in virtually all refining processes—even steam as in water-gas manufacture is a catalyst in the air-oxidation process

Part I

By RAFAEL FUSSTEIG

RAFAEL FUSSTEIG

has been affiliated with the petroleum industry since 1923, principally as chemist and engineer—At present he is professor of petroleum technology in the Ecole Superieure Technique et Commerciale de Paris, Paris, France, and maintains an office as consulting petroleum engineer at Jaroslaw, Poland, Kraszewskiego, 16.

ONE of the most interesting problems in the oil-refining industry involves the decomposition of hydrocarbons by catalytic air-oxidation. The decomposition is able not only to cause the splitting of higher molecular hydrocarbons into lower molecular compounds but also it may cause certain destructive oxidation reactions that result in the formation of smaller oxy-hydrocarbon particles. Zaloziecki, a Polish investigator, was the first to study this problem. He submitted[1] petroleum products to a distillation process in the presence of oxygen and obtained great amounts of "sour" water that contained different organic acids. In these experiments, Zaloziecki demonstrated that air plays a very important part in the ordinary distillation process.

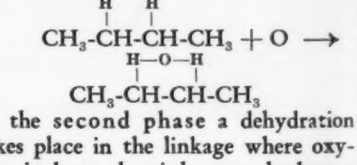
Lissenko[2] has continued the studies of this problem, distilling a neutral kerosene under normal conditions. The product obtained after the distillation showed a sour character. In the presence of carbon dioxide, however, the distillation of the same kerosene led to the production of the same neutral kerosene. This proved that the formation of oxy-hydrocarbons during the distillation process was caused, not by the oxygen of the hydrocarbon molecule, but only by the oxygen of the air. Consequently, there is ample evidence to indicate that certain decomposition reactions during the distillation of crude oil in a shell-still result from the action of air. Temperature and contact time are, of course, important factors that also must be considered.

It has been stated by many investigators that a lower percentage of air in the atmosphere of the shell-still during the distillation will result in a lower amount of decomposition. During the distillation process the oxygen of the air acts catalytically on the hydrocarbon vapors causing certain decomposition processes under proper operating conditions and in a proper reaction sphere. This reaction results in the formation of smaller hydrocarbon molecules and oxy-compounds. Very small amounts of these compounds are formed during the distillation process, the amount depending upon the temperature and the contact time. The distillation of higher molecular hydrocarbons, which requires a higher temperature and a longer contact time, yields greater amounts of decomposed and oxygenated compounds than does that of the lower molecular hydrocarbons, which requires only lower temperatures and a shorter contact time. During the distillation of a crude oil, therefore, gasoline will not be decomposed, but the heavier fractions may be affected so that the cylinder stocks show the greatest effect of decomposition.

Gasoline, when submitted to a temperature higher than that at which it vaporizes, will also be attacked by the catalysis of the oxygen of the air. M. Freund and G. Palik[3] have conducted experiments to obtain the catalytic air-oxidation of gasoline. Gasoline vapors and air mixed at a temperature of 400°-500°C. were passed through petroleum coke to obtain pyrolysis and oxidation reactions simultaneously. These investigators observed the formation of unsaturated hydrocarbons, as well as that of alcohols, phenols, carbo-acids, and esters. In these experiments it was demonstrated that the air can cause different splitting reactions in the vapor phase. Donath[4] has shown that air also may cause a catalytic air-oxidation of hydrocarbons in the liquid phase. He conducted experiments in which pumice-stone particles that had been impregnated by a neutral crude oil of Kaukas were placed in a long iron pipe, after which the pipe was heated to a temperature of 120°-250°C., and then air was directed through it for several hours.

After this operation the pumice stone particles were extracted by means of warm water, the filtered extract being then acidified by hydrochloric acid, and shaken out with ether. The etheric extract presented a residuum containing large amounts of fatty acids. Donath has proved in these experiments that not only a catalytic destructive oxidation process takes place when hydrocarbon vapors come into contact with oxygen but also similar reactions occur when oxygen comes into contact with a liquid hydrocarbon. It should be noted, however, that the directions of these reactions differ from each other, that is, the end reactions—vapor-vapor, and vapor-liquid—result in the formation of other products. The catalytic air-oxidation, of course, acts differently upon various hydrocarbons.

When saturated hydrocarbons are submitted to catalytic air-oxidation, the oxygen attacks in the first phase the hydrocarbon in a proper linkage, forming a labile oxide, according to the following reaction:



In the second phase a dehydration takes place in the linkage where oxygen is bound with two hydrogen atoms, resulting in the formation of water and a splitting of the weakened linkage and a consequent formation of two smaller hydrocarbon particles. Under other conditions the oxygen enters into reaction with saturated hy-

[1] *Zeitschr. fur angew, Chemie,* 1891, p. 416.
[2] *Trudi Baku J.,* 1893, No. 2.
[3] *Zeitschr. fur angew. Chemie,* 1927, p. 368.
[4] *Chemiker Zeitung,* 1892, p. 590.

FITS LIKE A GLOVE

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drocarbons, forming in the first phase a corresponding peroxide, $CH_3\text{-}\overset{H}{\underset{|}{C}}H\text{-}\overset{H}{\underset{|}{C}}H\text{-}CH_2\text{-}CH_3 + O_2 \longrightarrow$ $\underset{H-O-O-H}{}$

$CH_3\text{-}CH\text{-}CH\text{-}CH\text{-}CH_3$, which may be either split in such a manner that two aldehydes are formed, or split into a hydrocarbon and an aldehyde, or, finally, split into a hydrocarbon and an acid. In the first case the hydrocarbon is split in the middle of the peroxide linkage so that each split particle contains an oxygen atom. In the second case the peroxide linkage is split in the middle but one oxygen atom combines with two hydrogen atoms to form a molecule of water, so that only one hydrocarbon particle will contain an atom of oxygen. Finally, in the third case the splitting will occur so that two oxygen atoms remain in one particle, thus forming one molecule of a hydrocarbon and one molecule of an acid.

When unsaturated hydrocarbons are submitted to catalytic air-oxidation the addition of one or two oxygen atoms takes place in the unsaturated linkage of the hydrocarbon and is then split so that either one or two oxygen atoms remain on the two carbon atoms of the later double linkages. The nature of the catalyst, of course, as well as the temperature, pressure, and contact time have an important influence. In selecting operating conditions, the following combinations are available: (1) normal pressure and high temperature, using a proper catalyst; (2) higher pressure and lower temperature, using a proper catalyst. and (3) higher pressure and higher temperature, using a proper catalyst. The time of contact between the starting material and the oxygen of the air can also be controlled in this process. With this flexibility in the choice of operations, it is apparent that a multitude of reactions may occur in the catalytic air-oxidation.

According to Piotrowski and Winkler[5] the catalytic air-oxidation can occur in accordance with the following six principal reactions:

1. Constructive dehydrogenation reaction:

$C_nH_m + {}_aO_2 \longrightarrow C_nH_{m-4a} + 2_aH_2O$,

2. Constructive oxidation reaction:

$C_nH_m + O_2 \longrightarrow C_nH_{m-2}O + H_2O$,

3. Destructive hydrogenation reaction:

$C_nH_m + {}_aO_2 \longrightarrow C_pH_q + C_xH_y + 2_aH_2O$,

whereby, $p+x=n$; $q+y+4a=m$

4. Destructive oxidation reaction:

$C_nH_m + 2O_2 \rightarrow C_pH_qO + C_xH_yO + H_2O$,

whereby, $p+x=n$; $q+y+2a=m$

5. Polymeric hydrogenation reaction:

$C_nH + O_2 \longrightarrow C_{2n}H_{2m-4a} + 2_aH_2O$,

6. Polymeric oxidation reaction:

$2C_nH_m + O_2 \longrightarrow C_{2n}H_{2m}O + H_2O$.

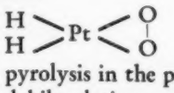
These reactions indicate that the catalytic air-oxidation of hydrocarbons presents a series of very complicated reactions accompanied by many intermediary reactions. The formation and flow of the intermediary reactions depend largely upon the nature of the catalyst. There are two types of catalysts capable of causing different kinds of reactions, the first being able to carry out destructive reactions combined with the hydrogen migrations, while the second catalysts contribute to oxidation reactions.

Furthermore, the pressure and the temperature have an influence on the flow of principal and intermediary reactions. Frolich and Wiezewich[6] have conducted experiments in which propane was cracked under normal pressure and a temperature of about 500°C. in a copper tube in the presence of about 70 percent air in the inlet gas and they have observed 75-80 percent conversion of propane into unsaturated hydrocarbons, consisting of ethylene and propylene in the ratio of 3:2. Small amounts of acetylene have also been formed in oxidative cracking. High pressure and low temperature conditions change the flow of reactions toward the formation of liquid organic oxidation products.

Lewis and Frohlich have carried out the cracking oxidation with propane at a temperature of 300°-350°C. and under a pressure of 2000 lb. per sq. in. They have reported the formation of 6 percent acetone, 22 percent methyl alcohol, 37 percent ethyl alcohol, 7 percent propyl alcohol, 11 percent formic acid, and 26.5 percent water. This indicates that propane in this case had undergone different decomposition and oxidation reactions and had resulted in the formation of different oxy-compounds.

Of course, the use of a proper catalyst promotes the flow of reactions but in such processes there is a risk of explosion if the operating conditions are not controlled. Cooper and Wiezewich[7] determined the explosion limits and stated that it should be safe to operate with methane at a temperature of about 400°C. under a pressure of 3000 lb. per sq. in. in the presence of less than 10 percent oxygen. In increasing the amount of oxygen present during the air-oxidation process it is advisable to employ a proper catalyst to avoid the hazard of explosion.

For this purpose platinum sponge seems to be a proper promoter, because it regulates the velocity of oxygen and hydrogen atoms in the flow of reactions. Willstaetter[8] believes that a coexistence of oxygen and hydrogen in the platinum molecule is likely, resulting in the formation of a labile superoxyhydroxide of platinum according to the formula:



During the pyrolysis in the presence of oxygen this labile platinum compound plays the role of a distributor of oxygen and hydrogen placing them into corresponding linkages of the split hydrocarbon atoms. In other words, this promoter causes a migration of hydrogen and the placing of oxygen on the valences "indicated" by the temperature and pressure.

This phenomenon leads to the formation of different oxy-compounds. It has been stated that platinum results in a better catalytic action not only in the abovementioned process but also in the catalytic destructive hydrogenation process when the reactions flow in the presence of oxygen. This phenomenon has been observed by different investigators who have reported that a hydrogenation process yields better results when small amounts of oxygen are present in the reaction sphere of the respective catalyst.

Boeseken and Hofstede[9] have stated that a hydrocarbon will be better hydrogenated by the platinum colloid when the hydrogen contains certain amounts of oxygen. They believe that this platinum is always set free from a pyrolysis layer by means of oxygen. In other words, the oxygen used for the cracking oxidation reactions of petroleum hydrocarbons is not only activated by the platinum catalyst but the platinum itself is steadily regenerated by the same oxygen molecules. In the opinion of the writer each decomposition process is promoted by the presence of oxygen. Even the modern cracking operations are affected by the presence of oxygen because it is virtually impossible to remove all air from the apparatus. The presence of even small amounts of air acts catalytically on the decomposition processes. This is because oxygen weakens certain linkages causing them to split into smaller particles. This hypothesis of the writer is supported by the small amounts of water vapors and carbon dioxide always found in cracked gases.

[5] *Petroleum Zeitschr.*, 1938, No. 16.

[6] *Journ. Ind. Eng. Chem.*, 1935, p. 1055.

[7] *Ibid.* 1929, p. 1210.

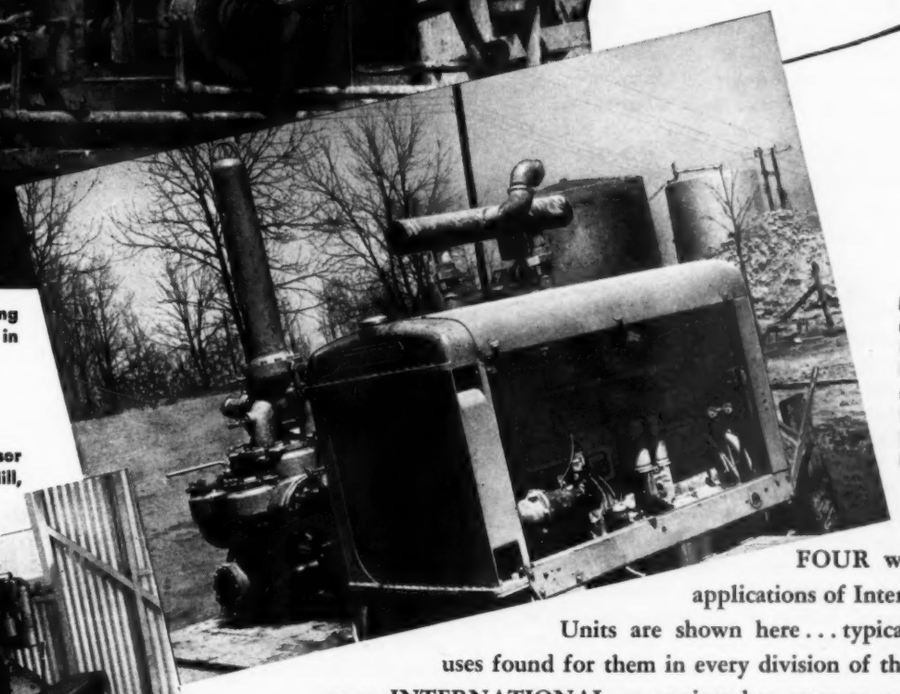
[8] *Berichte*, 1913, p. 527, and 1918, p. 767.

[9] *K. Akad. V. Wetensch. te Amsterdam Proc.*, 1917, p. 424.

EDITOR'S NOTE: Part 2 of this article will be published in the January issue.

WHAT'S *Your* POWER PROBLEM ?

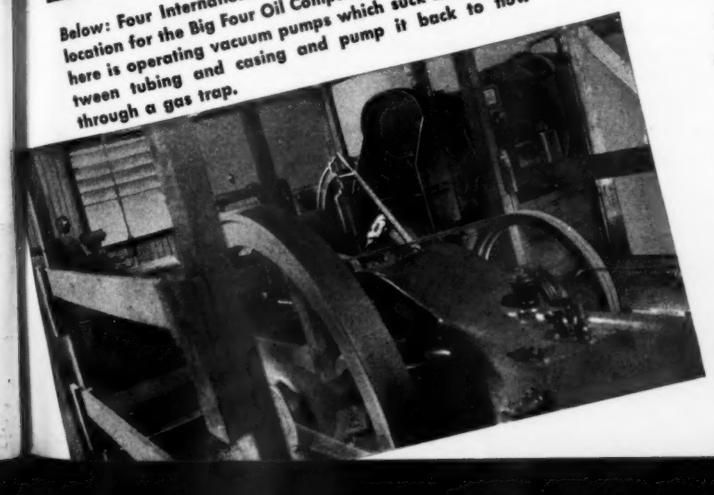
Above: An International PA-100 Power Unit, operating on butane, driving a portable rig in the Louden field in Illinois for the Stewart Oil Company.



Left: **Another International PA-100, using butane as fuel, hooked up to the slush pump by the Haynes and Thomas Drilling Corp., Salem, Ill.**

Below: Two International PA-100's powering a compressor to force oil and gas from a 10,157-ft. well at Signal Hill, California. Production was averaging 325 barrels a day when this picture was taken.

Below: Four International Engines are on this California location for the Big Four Oil Company. The engine shown here is operating vacuum pumps which suck the gas between tubing and casing and pump it back to flow through a gas trap.



FOUR widely different applications of International Power Units are shown here . . . typical of the many uses found for them in every division of the industry. The name INTERNATIONAL on engines has come to mean *dependable operation, low-cost power,* and *great adaptability.* So when a power problem comes up, it is natural for the men who have to get results to look to International Engines for a ready, successful solution.

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Electric Submersible Well Pump Performance in the St. Louis Pool, Oklahoma

Energy consumption and lifting costs for producing oil from average depth of 4100 ft.

By W. H. STUEVE
Oklahoma Gas and Electric Company,
Oklahoma City, Oklahoma

IN an area consisting of about 5000 acres, or eight adjacent sections, 5 miles wide east and west by 1½ miles long north and south, situated a few miles south by east of the town of St. Louis in Pottawatomie County, Oklahoma, is the field known as the St. Louis-Pearson pool of the Seminole field proper.

It produces from an average depth of 4100 ft. from the Simpson Dolomite formations and contains about 800 wells, 61 of which are equipped with Reda electric submersible well pumps. The first of these pumps, of 97½-hp. capacity, were tried out in this field in 1934. Fluid was lifted at the rate of 1700 bbl. per day average. The average energy consumption was 1.35 kw-hr. per bbl., and the overall efficiency from wire to fluid in the surface tanks about 45 percent. The average oil recovered was approximately 9 percent of the total fluid pumped when considered over a period of years for all pumps of this type in use. Some wells produced as much as 65 percent oil and about one-half of the total wells equipped with these pumps have produced from 15 to 20 percent oil during recent years.

During 1935 the average number of these pumps in use in this field was nine; today there are 61 pumps in use (see Fig. A). The upper graph in Fig. A shows the average amount of energy consumed per month by each pump. The comparative evenness of this upper graph indicates the steady consumption of energy of approximately 58,000 kw-hr. per pump per month. The actual calculated average running time per pump is of the order of 90 to 95 percent during the 3½ years for which accurate records are available; namely, 1936, 1937, 1938, and the first half of 1939.

It should be mentioned that the data collected assume that each pump connected operated continuously for the entire 30 or 31 days during that month; actually, a pump that was operated only one or two days during the month studied was considered in some instances as being operated continuously during that particular month. If sufficient information were available on actual hours each pump operated each month, the running time would show values averaging perhaps 98 percent of the elapsed period studied.

W. H. STUEVE

received both mechanical and electrical engineering degrees from Ohio State University—Is a member of the Oklahoma State Board of Registration for Professional Engineers—Member of the American Society of Mechanical Engineers and the American Petroleum Institute—For the last 15 years he has been associated with the Oklahoma Gas and Electric Company, having charge of oil-field, pipeline, and refinery electrification—Recently he had added to his duties that of manager of the Department of Industrial Development.

Information was sought in the field on results being obtained in order to determine the performance of the pumps. The data shown in Table 1 are illustrated graphically in Fig. B, for the 5½-year period during which the pumps were in use. Fig. B shows the total amount of electric energy required, both purchased and company-generated, and also the total amount of fluid lifted each year. It is estimated that in 1939 electric power consumption will total 40,000,000 kw-hr. and that more than 31,000,000 bbl. of fluid will have been lifted. Possible changes in allowable oil production during the last six months of 1939 may distort somewhat these estimates of fluid that the pumps will have lifted for the year.

Referring to Table 1, it may be noted that the amount of fluid produced with company-generated power is relatively small compared with that produced with purchased electric energy. The amount of company-generated electric energy amounts to only 4.4 percent of the total electric power requirements of the entire field for operation of these pumps during the 5½-year period studied. Although the efficiencies of these pumps in use are approximately the same as those using purchased energy, the volume of oil produced in terms of percent of total fluid handled is of a constantly declining value; thus, in 1937, 4.62 percent was oil produced with company-generated power, in 1938 the oil recovery was only 2.98 percent and for the first six months of 1939 this factor became 1.78 percent when only one pump was in use. The decline in use of company-generated power from 1936 to 1939 may be noted in Table 1.

In order that a better perspective can be obtained of the performance of these pumps in the St. Louis field, the data for the 2½-year period, 1937, 1938, and the first half of 1939, are itemized in terms of annual average

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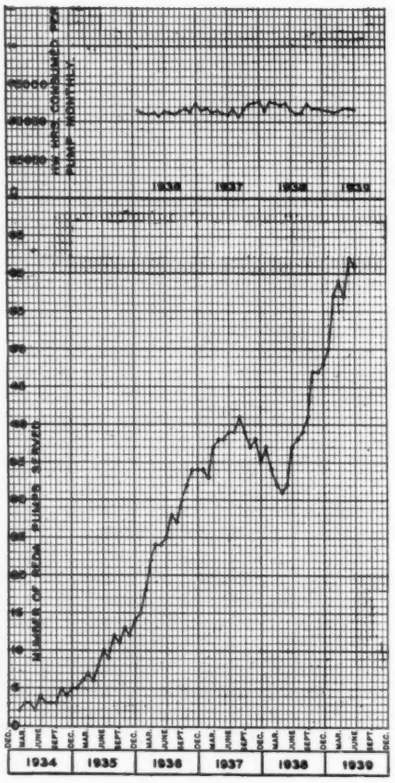


Fig. A. Showing gradual increase in number of submersible pumps installed in the St. Louis field, and electric energy required to operate them

TABLE 1

Fluid and oil produced, electric energy required by Reda pumps using purchased and generated power in St. Louis pool during 1937, 1938, and first 6 months of 1939. (Estimated production in 1934, 1935, and 1936)

Year	Fluid—total bbl. produced with electric energy		Oil—total bbl. produced with electric energy		Total electric power required, kw-hr.	
	Purchased	Generated	Purchased	Generated	Purchased	Generated
1934	1,550,000		140,000		2,100,000	
1935	4,400,000		400,000		6,200,000	
1936	12,600,000		1,070,000		17,819,296	400,000
1937	18,360,854	1,364,826	1,645,135	63,206	26,080,827	1,890,200
1938	21,394,599	1,115,112	1,804,467	33,268	27,316,692	1,510,000
Half of 1939	15,171,195	458,953	1,393,500	8,178	20,012,978	620,000
Totals.....	73,476,648	2,938,891	6,453,102	104,652	99,529,793	4,420,200

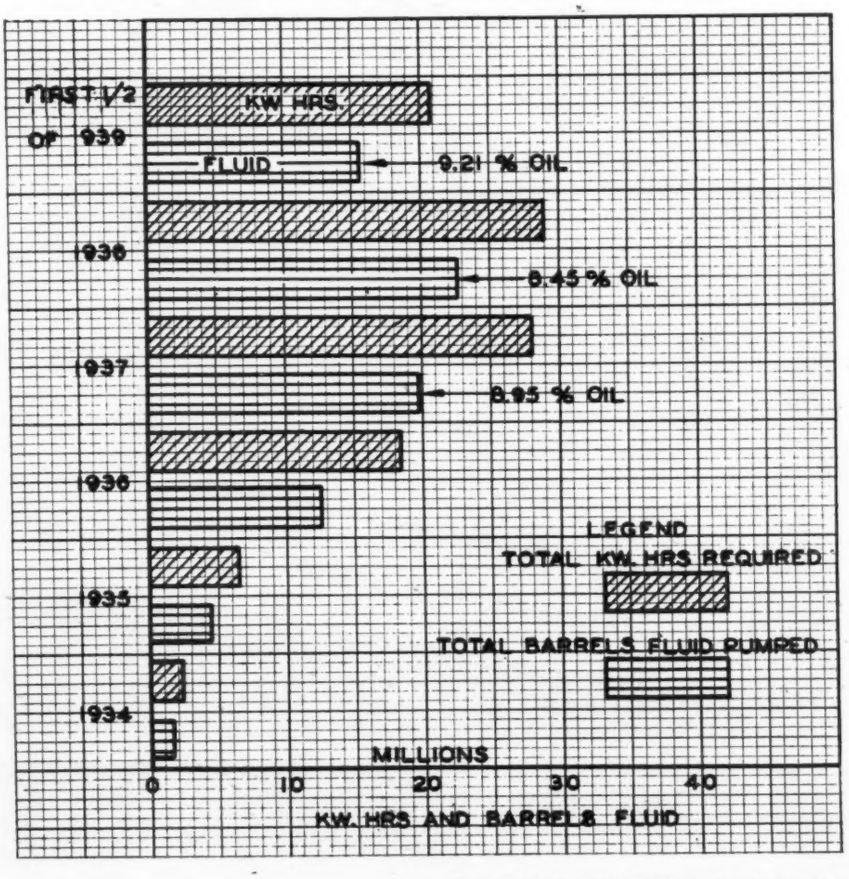
TABLE 2

Average daily production, energy per bbl. of fluid and oil, and efficiencies of those Reda pumps using purchased power

Year	Average number Reda pumps in use	Average daily production of fluid per pump, bbl.	Purchased electric energy required, kw-hr.		Overall* efficiency, percent	Percent oil of fluid pumped
			per bbl. fluid	per bbl. oil		
1937	37	1630	1.42	15.82	42.6	8.95
1938	39	1720	1.28	15.20	47.5	8.45
Half of 1939	58	1730	1.32	14.40	46.2	9.21

*Average pumping lift 4110 ft. sp.gr. of fluid 1.12

Fig. B. Annual energy required, purchased and generated, and total bbl. of fluid produced in St. Louis field from 1934 to July, 1939



overall efficiencies, energy required per bbl. of production, and percentage of oil being produced for all the pumps using purchased power.

These calculated amounts are shown in Table 2, and it may be noted how closely the averages are from year to year.

When the percentage of recovery appears to be very low, or when it becomes necessary to pump perhaps 11 bbl. of fluid to recover 1 bbl. of oil, this method of lifting oil may appear to be rather uneconomic when viewed from a standpoint of overall cost per bbl. of oil so recovered.

To evaluate properly all charges in order that the economy of the pumping operations being discussed may be determined, here are some figures regarding repairs and other costs. Over a period of two years, 1937 and 1938, all costs, such as repairs, transportation of equipment to and from the factory, running-in and pulling-out, total slightly less than 6 mills per bbl. of fluid pumped, and the total cost of lifting fluid, including electric power cost, is 2.1 cents per bbl.

Amortization of the pumping equip-

ment is not included in the above costs, for the reason that the equipment can be readily removed from one well and placed in another at such time as it becomes economically necessary. The flexibility of the unit with a given size electric motor permits pump impeller changes for a wide range of depths and volumes at a reasonable cost for application in other fields.

If these factors of amortization (high salvage value of the unit and interest on investment) are given their proper consideration, it may appear they should be entirely discarded in computing the lifting costs of fluid produced with these electric submersible pumps, and that only electric power and maintenance should be considered.

The operating cost data presented are for the St. Louis pool only, where the average pumping lift is 4110 ft., and the pumps are operating 90 percent of the time. If these pumps are considered for use in oil pools of greater or lesser depth, the costs per bbl. of fluid given above may be converted to the new condition by a simple process of proportion after making a slight correction for changes in the overall efficiency. Thus, the centrifugal pump will be perhaps 5 percent more efficient when used for a depth of 2000 ft. than for the depth discussed herein for the St. Louis field; but if used at a depth of 6000 ft. the overall efficiency may be 5 percent less, provided, of course, that the same capacity motor is considered for use in all cases.

Oil producers are interested in knowing the lower level of fluid and oil ratios at which the pumping charges overcome the oil revenue and cause production to become unprofitable. A barrel of oil sells for a given amount whether produced from deep or shallow horizons and the royalty holder usually receives one-eighth of the total oil produced free of all charges except gross production taxes.

Thus, it may be said that when pipeline oil is worth $1.00 per bbl. in the tanks, the producer realizes about 83 cents in revenue per bbl. of oil produced, after paying 5 percent State gross production tax and allowing for one-eighth royalty.

Assuming that daily maintenance and electric power costs are of a constant value at 90 percent operating time for any pumping depth, and that the same size motor is employed in all cases and slight changes in overall efficiencies are neglected, it may be said that the "break-even" (no profit or no loss) operating condition may be reached in wells 2000 ft. deep when the percentage of oil recovered

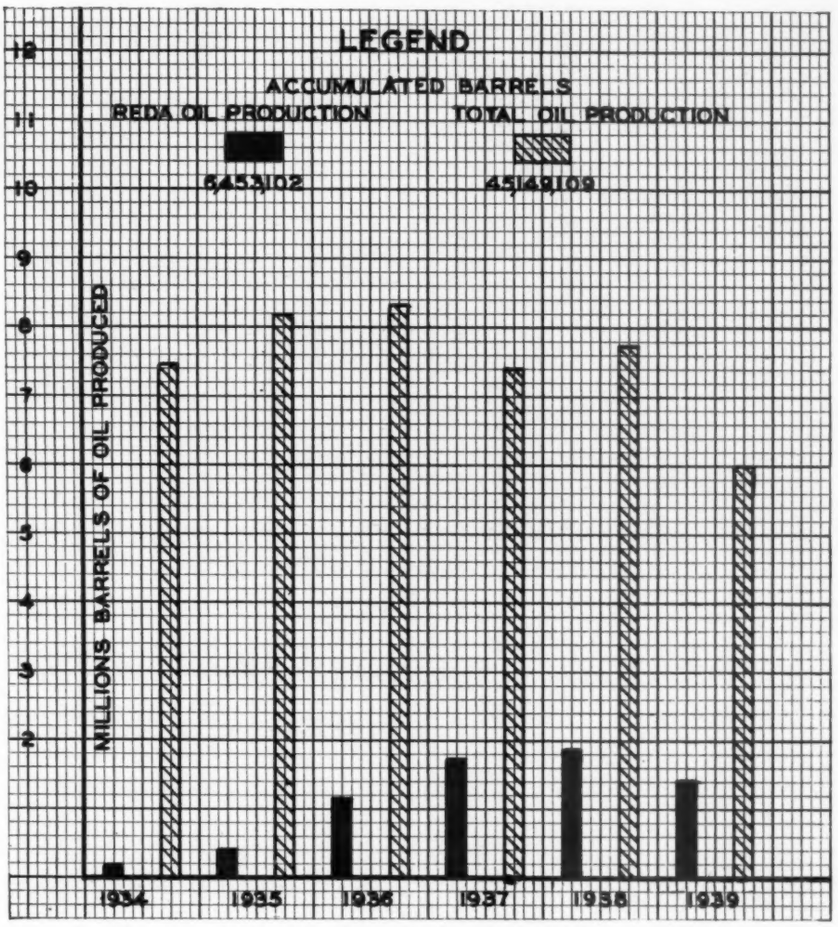


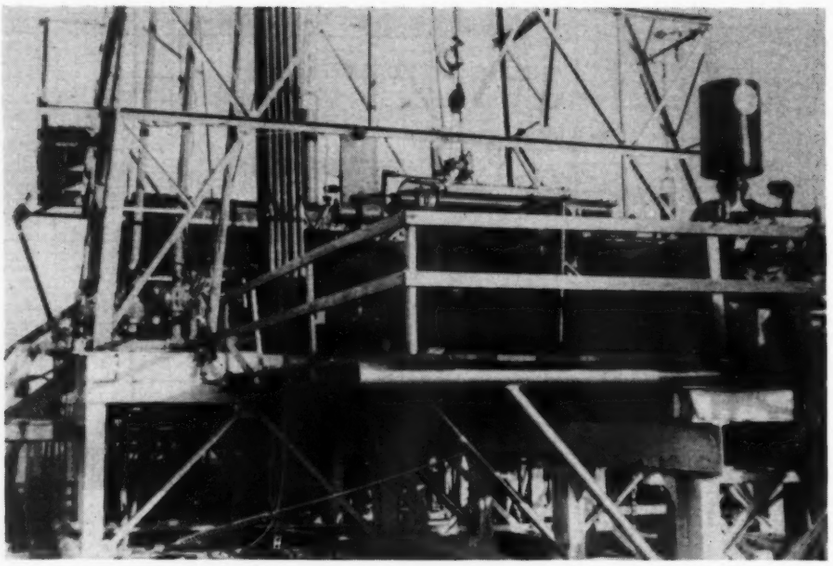
Fig. C. Total production of St. Louis pool compared to total oil produced with submersible pumps for 5½-year period. The 1939 total is for the first six months only

amounts to 1.5 percent of the total fluid (3400 bbl. per day) necessary to be pumped. In the St. Louis pool (1700 bbl. per day) this condition would be reached when the percentage approximates 3 percent or about 1 bbl. of oil to 30 bbl. of fluid produced. It is probable, however, that the operator would not continue on this non-profit basis very long; and perhaps a more conservative estimate of the ultimate pumping condition should be 20 bbl. of fluid to 1 bbl. of oil, provided, of course, the present price of pipe-line crude prevails in the St. Louis oil field. Average producing operations in the St. Louis pool yield 11 bbl. of fluid to 1 bbl. of oil. Lower lifting costs are an economic advantage to the operator, as they will prolong the pumping life of his wells.

The production curves for 1934, 1935, and 1936 provide a graphic representation of overall results obtained in the St. Louis pool and are based on estimated values of electric energy sold exclusively for submersible centrifugal pump operation during these years by using a value of 1.35 kw-hr. per bbl. of fluid produced, and 8.5 percent of such fluid being oil produced, both figures being the mean values of actual data assembled for the years 1937 and 1938 from Table 2.

During the 5½-year period studied, the total oil produced with these pumps in this field amounts to 14 percent of the field's total output during those years.

It is the experience of many operators that the conditions in many wells in the St. Louis pool require pumping at as high a rate as possible in order to obtain profitable operations. Many large capacity wells, when producing at the rate of about 400 bbl. per day, yield only water and a negligible amount of oil, yet, were the same wells pumped at a rate of 1400 to 1700 bbl. per day or greater, the percentage yield of oil to water would increase by as much as 9 or 10 percent.



Auxiliary drawworks as a precautionary measure

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
H. LEE FLOOD
Associate Editor

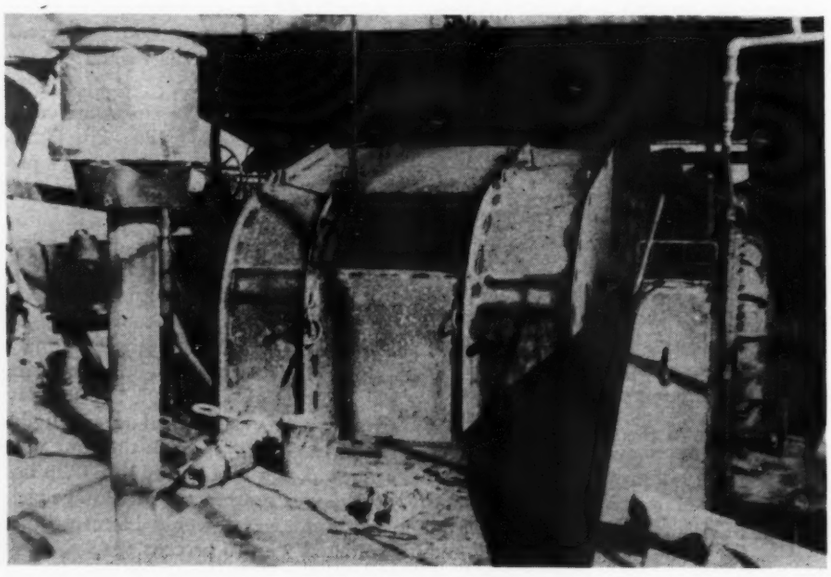
Deep Test in Oklahoma is Drilled By Diesel-Electric Rig

Continental Oil Company's No. 1 Proctor, drilled to 14,582 ft., is now second deepest test in the world

As the second deepest hole in the world and the deepest test in Oklahoma, the Continental Oil Company's No. 1 Proctor is the sixth test well in Oklahoma to be drilled deeper than 10,000 ft.

Interest in the test was sharpened when it was announced last February that the company had decided to set casing at 10,176 ft. and drill deeper in a test that had originally been planned only as an "8000- or 9000-ft." test. This interest increased as the hole was deepened. When a depth of 14,020 ft. had been exceeded the hole became the second deepest in the world, and there was much speculation concerning whether the well would "break the record" established last year by Continental's 15,004-ft. test in Kern County, California.

Now that drilling difficulties have prompted Continental to halt further drilling beyond the present total depth of 14,582 ft., the drilling operations on this test may be recorded. Most of the discussion here will be confined to a brief description of the drilling operations, drawing attention to features that may merit the attention of those who may encounter similar problems elsewhere.



This drawworks was used to drill the entire test

Drilling History

The drilling contractor, Fain Drilling Company, moved in equipment to drill No. 1 Proctor on July 27, 1938, and spudded-in on August 3. A 24-in. hole was drilled to set 250 ft. of 20-in. casing as a conductor string, cemented by 250 sacks of cement. Using 6-in. drill-pipe, a 17¼-in. hole was then drilled to permit setting 1477 ft. of 13⅜-in. casing as a surface string, cemented by 1500 sacks of cement. From

(Continued on Page 46)

PLANTS . . . CLARK "ANGLES"

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The process of distillate extraction and recycling of high-pressure gas has been one of the major developments in the oil industry, in the past 2 years. Of the distillate plants that have been constructed and placed in operation, in this period, 7 have selected CLARK "Angles" as compressor equipment.

The largest such plant at present in operation (see opposite page), has just installed its fifth CLARK 6-cylinder, 600 H.P. "Angle," and now totals 3000 H.P. of CLARK "Angles."

And the largest projected plant in this field, which will have a capacity of 140,000,000 cu. ft. of gas (see opposite page), will be equipped with five 8-cylinder, 800 H.P. CLARK "Angles," totalling 4000 H.P.

This is just a small part of the success story of the CLARK "Angle," in its first three years on the market. In this period a new compressor sales record has been achieved, of over 100,000 H.P. sold. This success has been attributable to unsurpassed mechanical efficiency, proven reliability, and to these 4 important savings, introduced by this machine: (1) Reduced Transportation and Erection Costs, due to shipment assembled; (2) Smaller Foundation, Floor Space, Building, due to compact design; (3) One-third Fuel Saving, due to CLARK Super-2-Cycle Fuel Injection; (4) Lowest Maintenance, due to simplicity of design and few parts.

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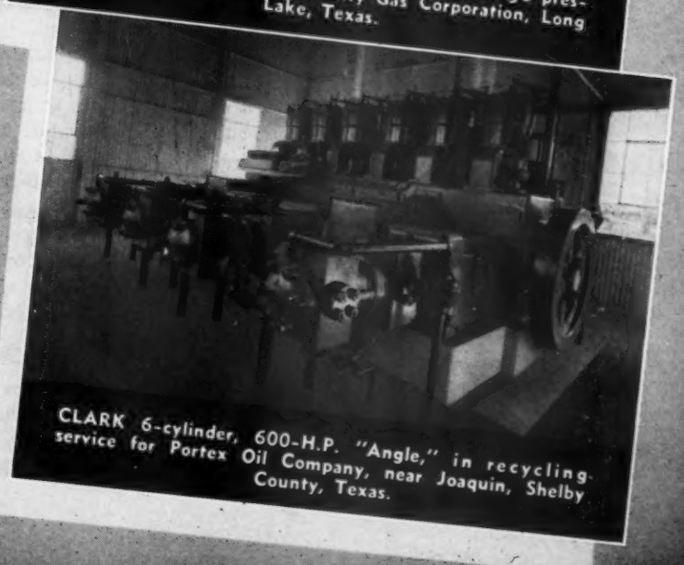
CLARK

CLARK 5-cylinder, 500-H.P. "Angle," in recycling service, Anco Gas Corporation, Byrd-Frost Plant, Palestine, Texas.

CLARK 600-H.P. "Angle," 4000 lbs. discharge pressure, in recycling service, Trinity Gas Corporation, Long Lake, Texas.



CLARK 6-cylinder, 600-H.P. "Angle," in recycling service for Portex Oil Company, near Joaquin, Shelby County, Texas.

(Continued from Page 42)

the depth of 1477 ft., the 6-in. drill-pipe was used to drill 12¼-in. hole to a depth of 6456 ft., using two 3-point reamers above and below a 40-ft. drill collar in addition to a rock bit. At this point, the 6-in. drill-pipe was laid-down and drilling was continued using 4-in. drill-pipe to drill 9-in. hole to a depth of 10,196 ft. Two 9-in. reamers above and below a 30-ft. drill collar were used in addition to a rock bit.

Having drilled to 10,196 ft. without obtaining satisfactory results, the Continental Oil Company then decided to continue drilling the test deeper, having no definite depth goal in mind.

It is important to emphasize that in beginning the well the contractor firmly believed that the ultimate depth would be only 8000 or 9000 ft. It is significant, however, that the Diesel-electric drilling rig moved-in initially by the contractor was capable, after minor changes, of drilling ahead successfully to the total depth finally reached.

The 126-ft., 24-ft. base derrick was replaced by a 136-ft., 30-ft. base derrick having a load capacity of 850,000 lb. A heavier steel substructure was installed and the drilling controls (blowout preventers, etc.) were modified slightly. The 1⅛-in. preformed drilling line was replaced with a 1¼-in. preformed drilling line and larger sheaves were installed in the crown block.

Previous to these changes, however, the 3740 ft. of 9-in. hole previously drilled was reamed to 12¼-in., using the 4-in. drill string on the bottom of which was a 1000-ft. length of 6-in. drill-pipe.

After the hole was thus enlarged to 12¼-in. to its total depth, a 9⅝-in. casing string was run-in and set and cemented at 10,916 ft. with 1600 sacks of cement containing 3 percent colloidal material. Three weights of external-upset casing were used in making-up the string—2950 ft. of 58-lb.; 1000 ft. of 47-lb., and 6226 ft. of 43.5-lb. casing, the heavier section being, of course, on the bottom of the string. Twelve hours were required to run the casing and two hours to cement it. This job was completed on February 27, 1939.

Drilling was resumed on March 6, 1939, using 4-in. drill-pipe and a 30-ft. drill-collar above the bit to drill 8¼-in. hole. The 12,000-ft. depth was reached during June, the 13,000-ft. depth was passed shortly after July 1, and a depth of 14,479 ft. had been attained when the drill-pipe stuck on August 12, 1939—a year and nine days after the hole had been spudded.

After using 1500 gal. of acid and a total of 145 bbl. of oil and resorting to other methods in an effort to free the drill-pipe, 12,229 ft. of drill-pipe was backed-off leaving 2250 ft. of the drill-string in the hole. An additional 2182 ft. of pipe was recovered by washing-over and cutting-out successive sections. Six successful cuts out of nine attempts were made from August 23 to September 5. All but 68 ft. of the string was recovered and, after several attempts to fish-out this remaining section, it was decided to side-track the fish.

On September 9, 100 sacks of cement were placed above the fish and allowed to set three days. Initial attempts to start a side-track were unsuccessful and another 75-sack batch of cement was placed in the hole. Using a standard rock bit, the cement was drilled and the fish was successfully passed.

Drilling was then continued to a depth of 14,540 ft. before the liner was installed. As a liner, 4779 ft. of 28-lb., 7-in. external casing was cemented at a depth of 14,491 ft., using 300 sacks of cement.

An attempt was made to cement the top of the liner, which was at a depth of 9712 ft., 464 ft. above the bottom of the 9⅝-in. casing string. When drilling was resumed in the 49 ft. of "open" hole previously drilled below the liner, it was found that the wall of the hole was caving. An increase in mud weight to combat this trouble caused circulation to be lost. Tests indicated the loss of mud was occurring at the top of the liner.

Re-cementing to obtain a shut-off was first tried in an attempt to pump cement behind the liner and then displace it into the formation by pumping mud in after the cement. Following this, cement was pumped-in in stages in an effort to form a bridge below the 9⅝-in. casing and behind the liner, and then seal-off the porous formations above.

After a shut-off had apparently been obtained, drilling was resumed. The shale continued to cave, however, resulting in the drill-pipe becoming stuck after a depth of 14,582 ft. had been reached. Backing-off and fishing resulted in recovering all but two joints of drill-pipe.

Following the siege of four months of almost continuous trouble, it was decided to abandon further attempts to deepen the test. Plugging-back and testing is now in progress.

Drilling Equipment

The most interesting features of the equipment used in drilling No. 1 Proctor were (1) the installation of a complete auxiliary hoisting unit and pump as a standby; (2) the re-designed electrical controls permitting extreme flexibility in operation, and (3) the opposed-piston Diesels used to drive the generators.

The standby drawworks, having 8-in. shafts, and powered by a 150-hp. Diesel was never used although its presence was justified in case of emergency.

The drawworks used throughout the drilling operation has 9-in. shafts and is driven by an electric motor rated at 350 hp. when operating at a speed of 750 r.p.m.

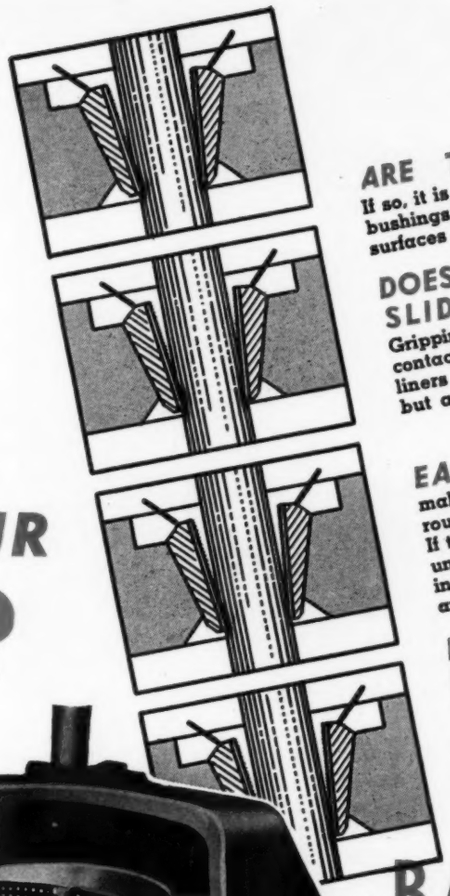
Two 7¾-in. by 20-in. mud pumps and one 7¼-in. by 14-in. mud pump were powered by a 300-hp. electric motor, a 225-hp. electric motor, and a 150-hp. Diesel engine, respectively. All electric motors on the rig were cooled by blowers.

The power plant consisted of two main units and one standby unit—two 300-hp. Diesels each driving 140-kw. and 60-kw. generators, both direct-connected; one 160-hp. Diesel driving a 50-kw. generator.

The re-designed electrical circuits and the additional power provided by the auxiliary generator permit all operations to be conducted simultaneously if desired. Mud can be circulated, jetted, and mixed while drilling or coming out of the hole. Any combination of generators can be used to supply power to any motor in the amount required at the time. The details of this arrangement are sufficiently interesting to warrant special discussion not possible here.

The opposed-piston Diesel engines employed on this rig have not been used extensively as drilling power although the design is employed widely in marine service. Operating on the 2-cycle principle, these 6-cylinder engines have, in reality, 12 cylinders. Six pistons, each 5 in. in diameter having a 7-in. stroke, are attached to a crankshaft above and six pistons are attached to a crankshaft below. Instead of compressing against a fixed head, as in an ordinary engine, the pistons compress against each other. The expanding gases resulting from the explosions thus exert force against both pistons simultaneously. The lower crankshaft is direct-connected to the generators; the upper crankshaft is linked to the lower one by an enclosed chain drive. Direct-connected to the upper crankshaft is an enclosed blower that supplies air under forced draft to the cylinders for the combined purpose of scavenging the

WHAT ARE *YOUR* SLIPS DOING TO *YOUR* PIPE?

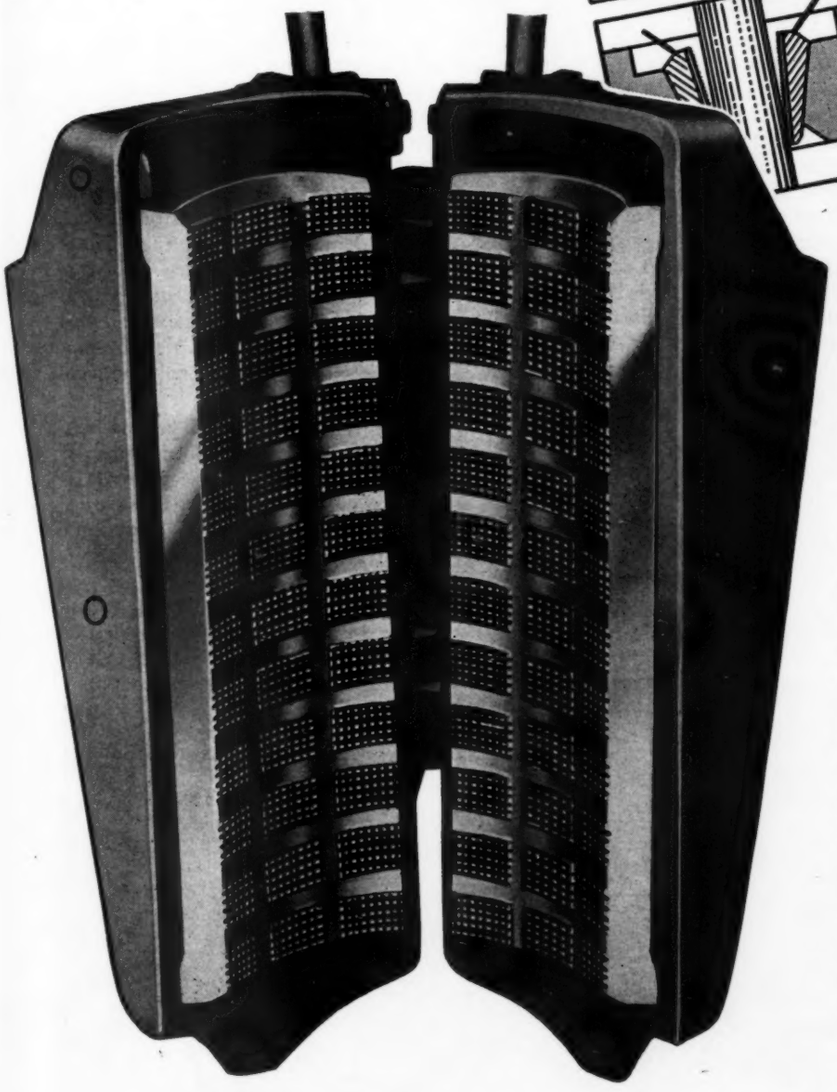


ARE THEY CUTTING YOUR PIPE? If so, it is probable that your slips are tilting in the master bushings so that, under load, only a portion of the gripping surfaces is in contact with the pipe.

DOES YOUR STRING CREEP OR SLIDE THROUGH THE SLIPS? Gripping surfaces must be aligned and in full-length contact with the pipe to support it efficiently. Even new liners cannot hold the string safely when they have but a partial grip on the pipe.

EACH SETTING? Wear and distortion make the bore of the master bushings out of round, hence the slips cannot seat concentrically. If the slips are not designed for lateral adjustment, uneven stress is concentrated on the pipe, resulting in a kneading action that quickly weakens and ultimately destroys it.

HOW ABOUT SWAGING UNDER HEAVY LOADS? Tremendous compressive stresses are imposed on a small area of the pipe when the slips tilt under load, or tilt because of wear or deformation of the master bushings or rotary. Full-length, uniform contact with the pipe of the gripping surfaces of *all* the slip sections is the answer to this problem.



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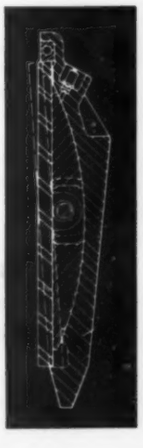
Examine the cross section sketch: it explains the Baash-Ross Self-Aligning principle. Note that the liners are supported upon segmental backing plates which can oscillate in the body. As the slips are set and the load applied, the gripping surfaces of the liners automatically align with the vertical axis of the pipe, taking a full-length grip. When the body sections tilt, as in a worn or distorted master bushing, the angular relation between the face of the liner and the tapered back of the body sections is immediately altered to compensate for the wear or distortion. A flexible hinge between the body sections provides *lateral* adjustment as well.



Stop the damage to your pipe and get the maximum in safe, effective suspension by using Baash-Ross Self-Aligning Rotary Slips. Write for the new bulletin which explains the Self-Aligning Principle in detail, or refer to pages 180 and 181 of your 1939 Composite Catalog.

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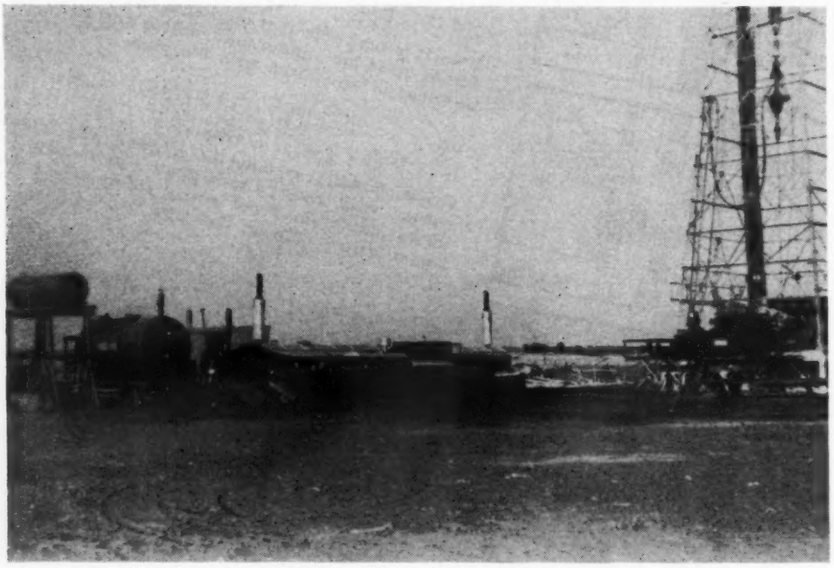


General view of the scene of operations

burned gases and of filling the cylinder in preparation for the next stroke. A description of this engine appeared in an earlier issue.[1]

Mud Control

Experience in drilling the No. 1 Proctor served to emphasize the importance of closely controlling the mud during the drilling of deep tests. Normal difficulties in the Proctor were augmented by the presence in the mud at various times of acid, oil, and drilled cement.

Only one complete mud change was required during the entire operation and this was after the plug had been drilled following setting of the 9⅝-in. casing.

Gas encountered at approximately 10,900 ft. occasioned a most exacting control of the mud density between limits of 10.6 and 10.9 lb. per gal. Below 10.6, gas would cause trouble; above 10.9, circulation would be lost.

The first 10,000-ft. test drilled in Oklahoma (and the second drilled in the world) was completed in the Fall of 1931. This was the No. 6 Preston-Culp drilled by Ramsey Petroleum Company and Mid-Kansas Oil and Gas Company in the Cement field, Caddo County. This well, like the Proctor, failed to find commercial production, although several indications of oil were logged. A string of 6⅝-in. casing was set in the Preston-Culp well at a depth of 9777 ft.; in the Proctor well, 9⅝-in casing was set at 10,176 ft.

Since the first 10,000-ft. tests were drilled in 1931, more than 300 wells have been drilled to depths greater than 10,000 ft. This number of wells has enabled the industry to work out the problems presented by deeper drilling and, in general, today's equipment and methods that serve to drill to depths of 10,000 ft. have been shown to be adequate also for 15,000-ft. tests.

There is little in connection with the drilling of Continental's Proctor well to distinguish it from other deep tests that have been drilled. The actual drilling of the well required approximately 12 months. It was not until the drill-pipe became stuck that any real trouble was encountered.

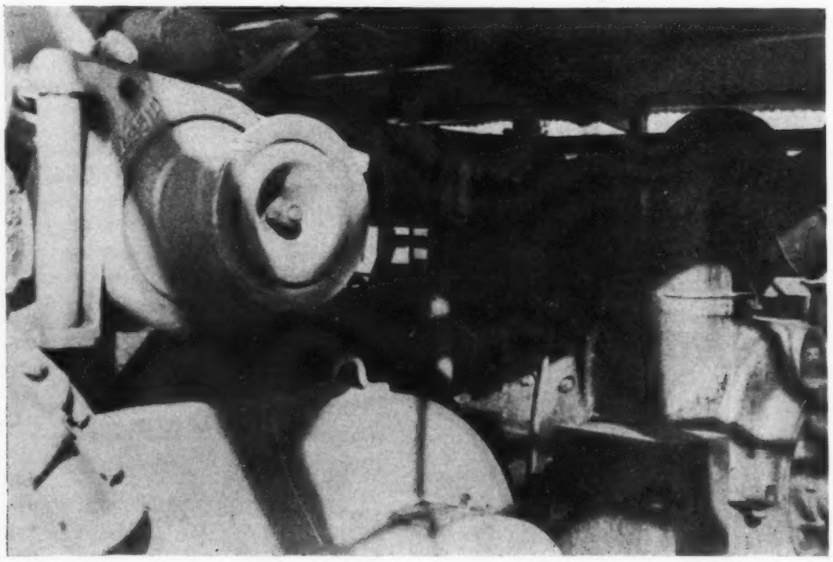
Purpose of the Test

The Proctor well is approximately 8 mi. south and 4 mi. west of the town of Elk City and about 115 mi. west of Oklahoma City. Exact location is in NW ¼ 28-10n-20w, Washita County.

Geologically, the well is situated in the Anadarko Basin, an area that has long been looked upon by geologists as a potential source of oil production but about which comparatively little is known. As a wildcat, the Proctor well, in addition to being a definite effort to obtain new production, was planned by the Continental Oil Company as a source of geologic information that would aid in evaluating the potentialities of the large blocks of acreage leased by the company in the area. One of the objectives, consequently, was to penetrate the Pennsylvania series and thus determine the thickness and lithology of this important part of the geologic column. Halted before the base of the Pennsylvanian had been reached, the test succeeded in penetrating nearly 9500 ft. of the Pennsylvania series, of which 4650 ft. consisted of the Strawn group. A source of oil and production elsewhere, the Strawn in the Proctor well disclosed the presence of gas in several horizons between depths of 10,700 and 13,400 ft., indications that are even now being tested to determine whether they may be exploited economically.

Had the Proctor well proved productive, it would have added materially to the oil possibilities of western Oklahoma, now only spotted by commercial developments. Nearest oil production to the Proctor test is in the Granite pool, about 18 mi. south; nearest gas production is in the Sayre field, 18 mi. distant in a southwesterly direction.

[1] "Opposed Piston Diesel Drilling Power Plant," by K. C. Sclater, *The Petroleum Engineer*, May, 1936.



The 350-hp. motor driving the hoist was cooled and vented by a blower, seen at the right of the picture

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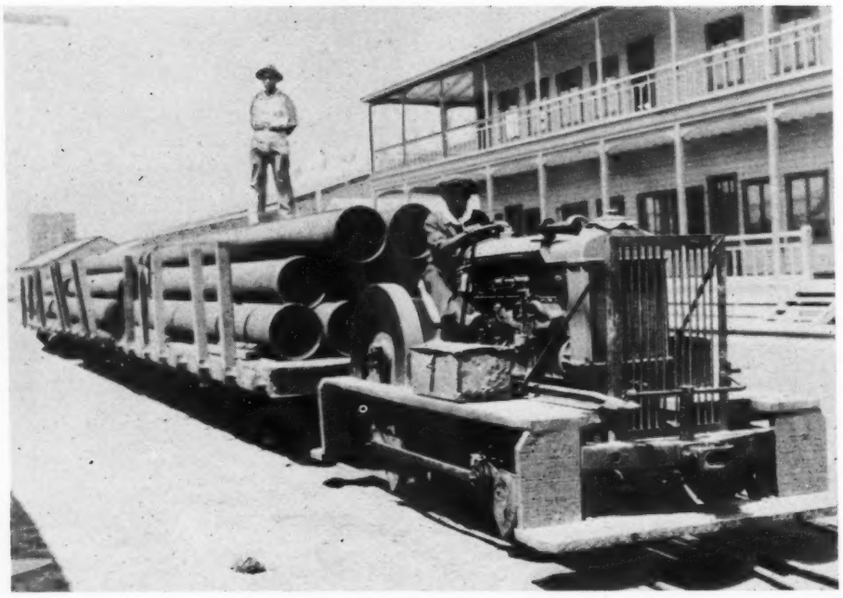


A Fordson rail tractor used by the railroad

PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
E. C. BREENE, JR.
Assistant Production Engineer,
International Petroleum Company, Negritos, Peru

Company-Owned Railroad Important to Operation and Development of Oil Fields in Peru

International Petroleum Company's narrow-gauge railway, 60 miles in length, connects 14 producing areas in northwestern Peru

FEW industrial railway systems serve their purpose more adequately than does the International Petroleum Company's narrow-gauge railway in northwestern Peru. Stretching across an arid tablazo, its 60 miles of main line tie together 14 separate oil fields. In the operation and development of these fields, the railroad plays an important part.

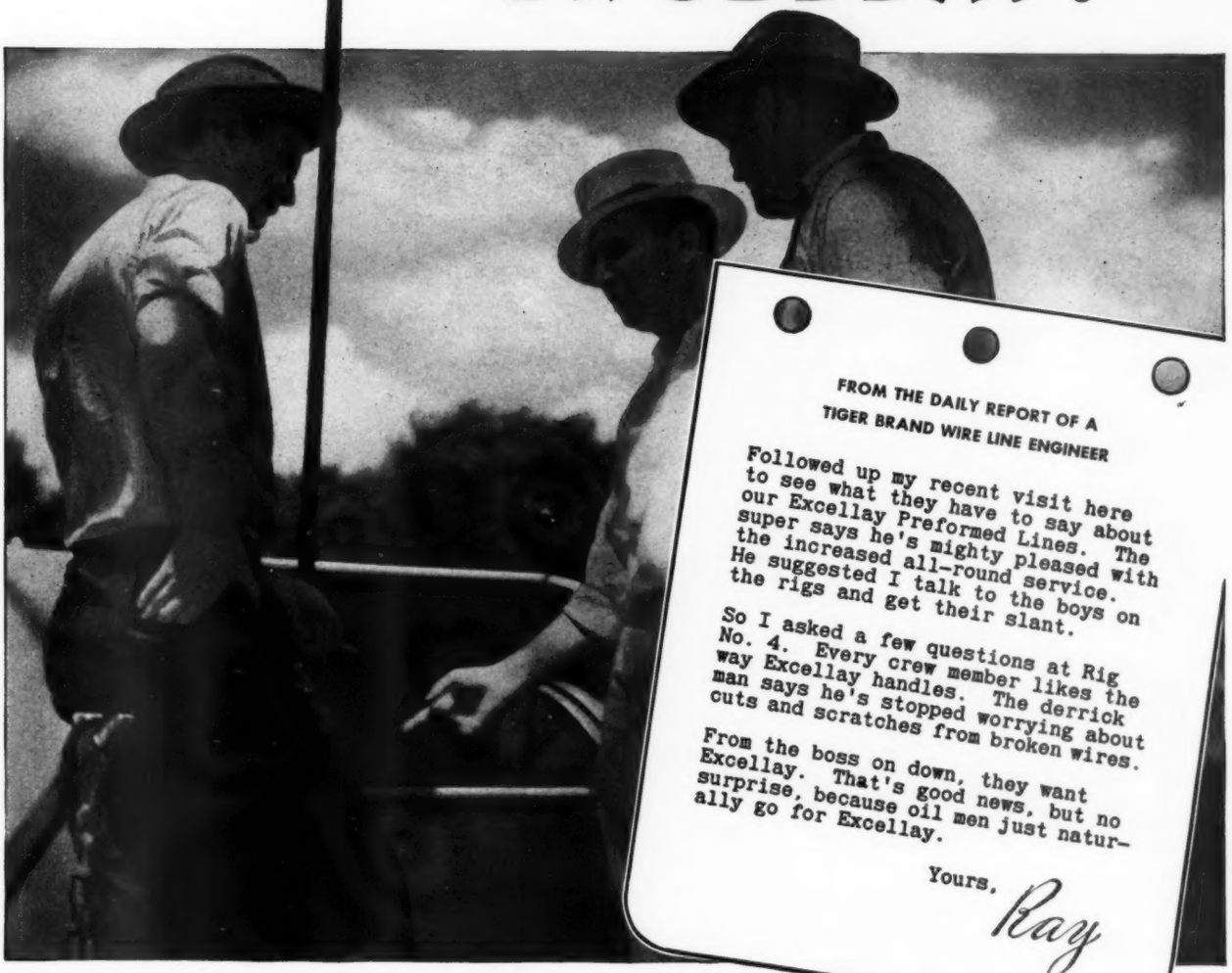
From the oil-fields' operating center, the town of Negritos, two main systems emanate. The first runs northward 6 miles to the seaport of Talara. This is a single track of 30-in. gauge connecting the docks and the main supply houses in Negritos. Over this system pass all imported equipment and material necessary to the operation of the oil field. Not far south of Talara the line tunnels through a narrow range of hills that for years formed a natural barrier to intercamp transportation. Prior to the construction of this tunnel in 1920 all material for the oil fields had to be hauled from the Talara flats by inclined railway to the adjacent coastal plateau and transported from there by rail to Negritos. Although built at considerable cost, this tunnel has proved to be a valuable investment for the company. The second and larger of the two railroad divisions is that which services the oil fields proper. Principal lines of this division branch to the north, east, and south of Negritos and penetrate well into the center of every producing district. From these emanate many spur lines that further facilitate well and construction work. So complete is the network of this division, that of the 1965 wells in operation by the company a large percentage of them can be reached by the construction of a short extension of the present lines. The southernmost terminal of this field division is the Portachuelo pump station situated on the north bank of the Chira River, about 15 miles south of Negritos.

THE AUTHOR

E. C. Breene, Jr., is a graduate in petroleum engineering from the University of Pittsburgh—His experience consists of one year spent in the oil fields of Pennsylvania and five years as petroleum engineer with the International Petroleum Company, Negritos, Peru.

In operating the railroad, the traffic department uses several types of locomotives. Light loads to and from the field are generally moved by small Fordson tractors that have been converted to railroad work in the local shop. There are 14 such units in service at the present time. Available for the same class of work are six English-made Simplex railcar tractors. The latest addition to this group is a new type shown in an accompanying photograph. This machine, constructed recently in the company factory at Negritos, is powered by a Ford V-8 motor and is heavier, faster, and more powerful than the other types mentioned. It also has the added advantage of three speeds in reverse. The new car has met with great success in light-load work and undoubtedly a similar type will replace the 4-cylinder Fordsons eventually. For intermediate loads the department operates two Baldwin gasoline locomotives. Heavy freight and workmen's passenger trains are drawn by 16-ton Baldwin steam

OIL MEN JUST NATURALLY GO FOR EXCELLAY!



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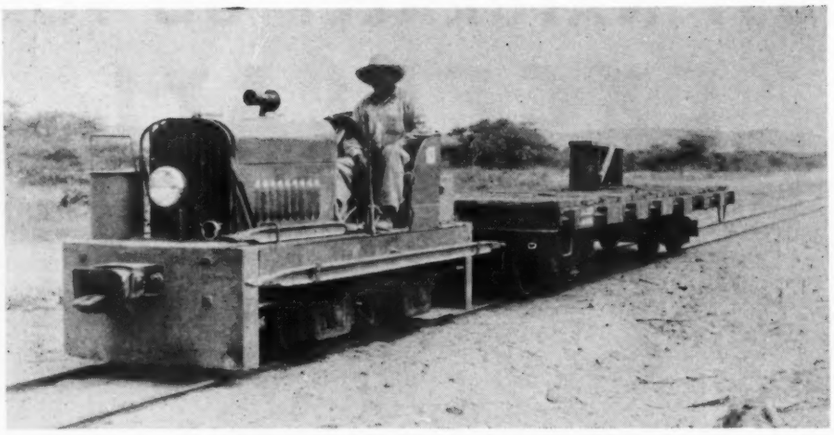
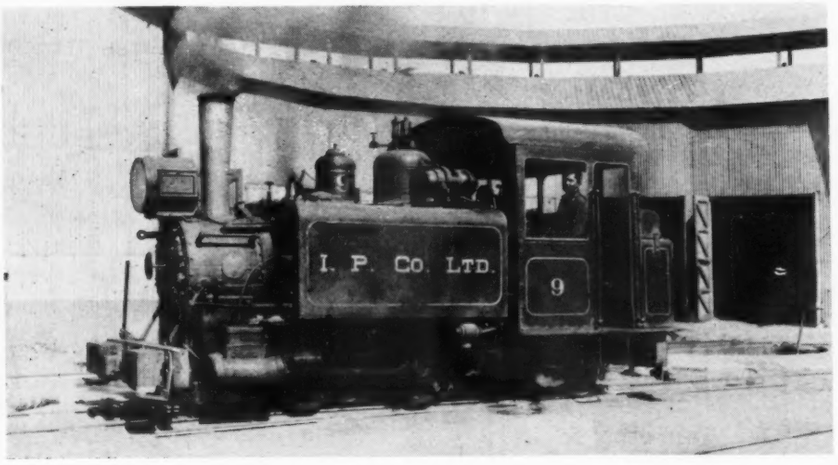
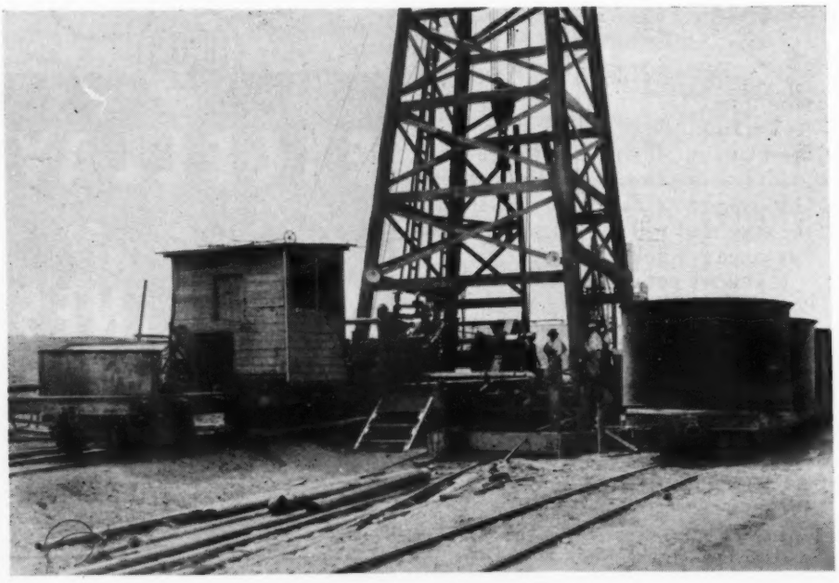


The newest-type rail tractor placed in use by the railroad



Heavy freight and passenger trains are drawn by 16-ton steam locomotives such as this



Rotary rig mounted on a flat car, used for shallow drilling and deepening work to 2000 ft.

locomotives. Although there are seven of these on the property, normal railroad traffic requires the use of only three. Steam engines are used throughout the entire Negritos division of the road, but on the Talara section they run only as far north as the tunnel. The timbered walls of the tunnel create a fire hazard and for this reason the entrance of the steam locomotive is prohibited. For line inspection and special service three Ford pickups and two Ford touring cars are used. Of the 300 cars available for railroad use, 120 are of special type such as passenger and tank cars, and oil-well servicing units.

An interesting feature of the railroad system that seems to be singularly characteristic of the Peruvian oil field is the combination of asphalt runways bordering either side of the track, making automobile travel possible along the railroad bed. Extension of the ties on both sides of the rails affords adequate foundation for the surfacing material. Turnouts placed at convenient distances along the road bed permit two-way traffic without undue delay. Asphalt earth dug by workmen from the historic oil seeps near the foothills of the Andes is used for the surface material. Considerable saving in the cost of highway construction has been effected in this way.

A great share of the total railroad business is concerned directly with the drilling industry. All of the large rotary rigs, of which there are six in operation at the present time throughout various parts of the field, depend almost entirely upon the road not only for their mobility, but for their miscellaneous supplies and equipment during drilling time. Drilling wells in active rotary areas are connected by rail to the local field supply house and drill-pipe racks. In moving such type rigs, several flat cars are run into the well siding. When they are loaded a tractor spots more cars in their place and hauls the loaded part of the rig to the next location. Ten cars are usually sufficient to move a complete rig. During moving jobs, tractors also aid in snaking heavy machinery across the derrick floor to the flat car. At the present time the largest single piece of equipment moved in rotary work is a unitized drawworks weighing approximately 30,000 lb. In the movement and erection of the department's nine steel drilling derricks these tractors are equally useful. Each rig-building crew has a small supply car that carries necessary tools and accessories.

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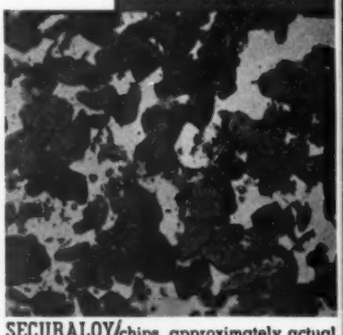

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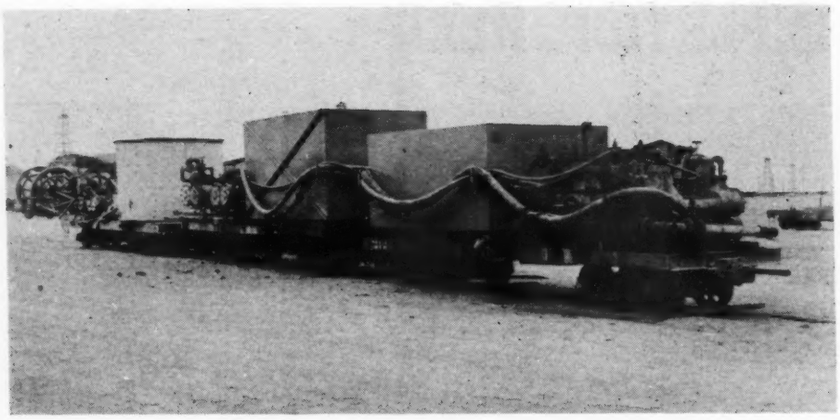


Oil-well cementing units mounted on flat cars. These are employed in ordinary cementing work as well as for high-pressure squeeze-cementing jobs

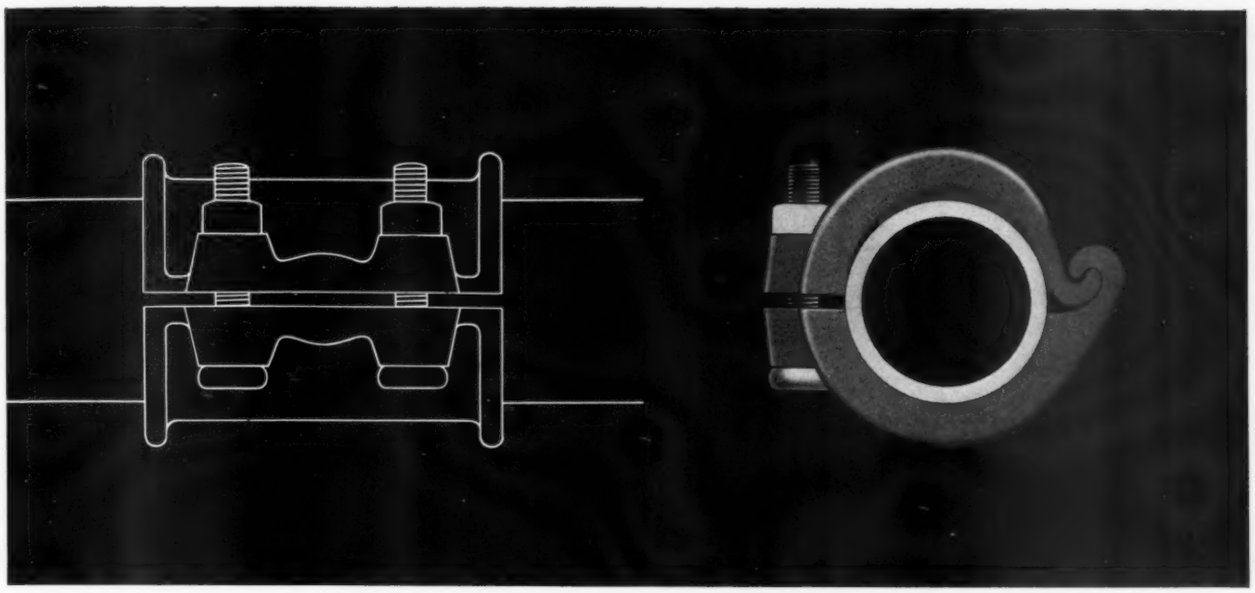
Once a week the people from the Chira River district travel free of charge to the Negritos market where they sell their farm products

Asphalt runways border each side of the railroad's tracks, providing a smooth road for automobile travel

The standard-tool rigs are offered the same facilities by the railroad as are given the rotary. Both receive all of their casing by rail. Some of the drilling department's most useful units are permanently mounted on flat cars. Since 1937 a flat-car-mounted rotary rig has been in constant service. For shallow drilling and deepening work to 2000 ft., this rig has proved very successful. On one car are mounted a two-speed drawworks, a 10-in. by 10-in. twin drilling engine, and a 12-in. by 6-in. by 16-in. mud pump. One of the illustrations shows this rig on a deepening job in the 16-Section pool district. In parts of the field such as this, that are far removed from the main rotary section, mud is hauled to the rig by rail. Complete moving time for this rig from one location to another requires about 16 hours, which includes time required for tearing-out machinery from the old location and moving and rigging-up on the new. This outfit was built in the Negritos machine shop from second-hand rotary equipment. Also on special cars for drilling service are four oil-well cementing units. Three are used in ordinary cementing work; one is reserved for high-pressure squeeze cement jobs. This last-mentioned assembly consists of two 14-in. by 5-in. by 12-in. pumps having a rated maximum working pressure of 3500 lb. per sq. in. Flat-car-mounted mixing boxes are used in connection with cement work.

In addition to its valuable function of servicing the oil fields themselves, the railroad plays a vital part in the life of the Peruvian population. It is difficult to estimate the number of people depending upon it for their food supplies, but local authorities say that in the oil fields proper between 13,000 and 14,000 people depend upon it. To them the railroad has become an institution for it means, to a large measure, their livelihood and transportation. Once a week the people from the Chira River district travel free of charge to the Negritos market where they sell their farm products. An average of 3500 people and 70 produce cars are transported from the river terminal each month. Besides this service, regularly scheduled trains offer free transportation twice a week from the oil fields to Negritos for the workmen and their families.

In the petroleum industry, this small railroad is unique. Although it serves an industrial purpose to its owners it is, at the same time, the sole means of transportation for hundreds of people.



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Pipe sizes 1/2" to 12". Also available in longer length, known as SKINNER-SEAL Pipe Line Clamp—for long splits or bad corrosion. Other SKINNER-SEAL clamps, such as Pipe Joint Clamp, Collar Leak Clamp, and High Pressure Weld Clamp, for specific conditions.

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M. B. SKINNER CO. *Est. 1898* SOUTH BEND, IND.

P 213.2
P 677.

Temperature-Gravity Graph For Gravity Determinations

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

A useful graph constructed from A.P.I. gravity tables

By O. G. VANDERVEER

Engineering Department, Sinclair Refining Company, Pipe Line Department, Kansas City, Missouri

IN the transportation of crude oil and gasoline by pipe line it is a customary practice to maintain a record of the true gravity of the oil passing each pumping station. The true gravity is determined from observed gravity readings taken at fixed intervals of the oil in the line, and also periodically of the oil in the tanks not used for working tanks. This is necessary in order that the dispatcher's records will show, at all times, exactly what oil is being moved throughout the entire system.

The usual procedure in reading the hydrometer for gravity determinations is, first, to read the observed A.P.I. gravity, taking the reading to the nearest one-tenth of a deg., then immediately thereafter to read the temperature to the nearest degree. These readings are then recorded, together with the corresponding computed, or true, gravity, based on 60 deg. fahr., which

O. G. VANDERVEER entered the employ of the Prairie Pipe Line Company, Engineering Department, in 1929, his first affiliation with the oil industry, remaining until 1932, the year the company was consolidated with the Sinclair Refining Company. In 1934 returned to staff of the organization by then known as the Sinclair Prairie Pipe Line Company but subsequently changed to Sinclair Refining Company, Pipe Line Department. Has been there since.

Fig. 1. Temperature-gravity graph for gravity determinations

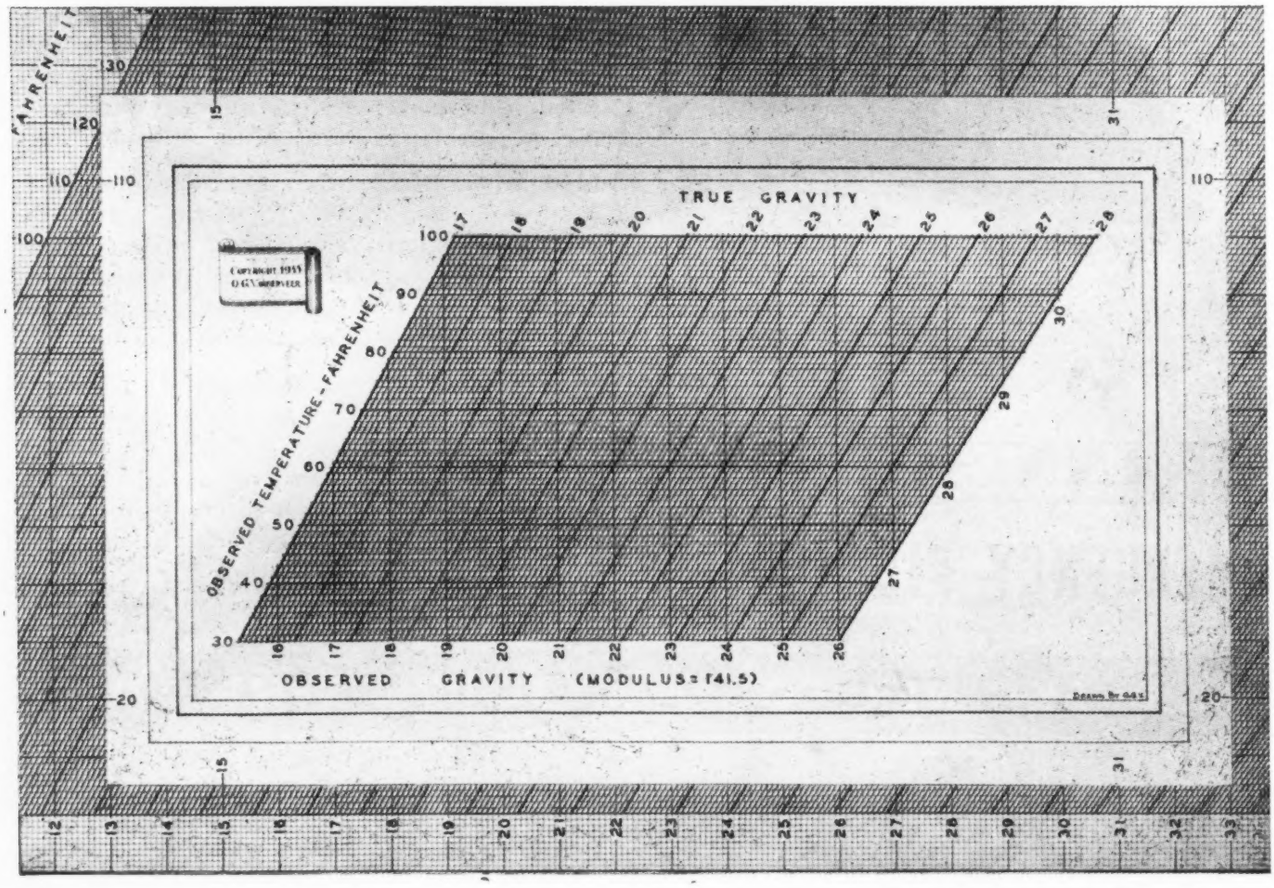
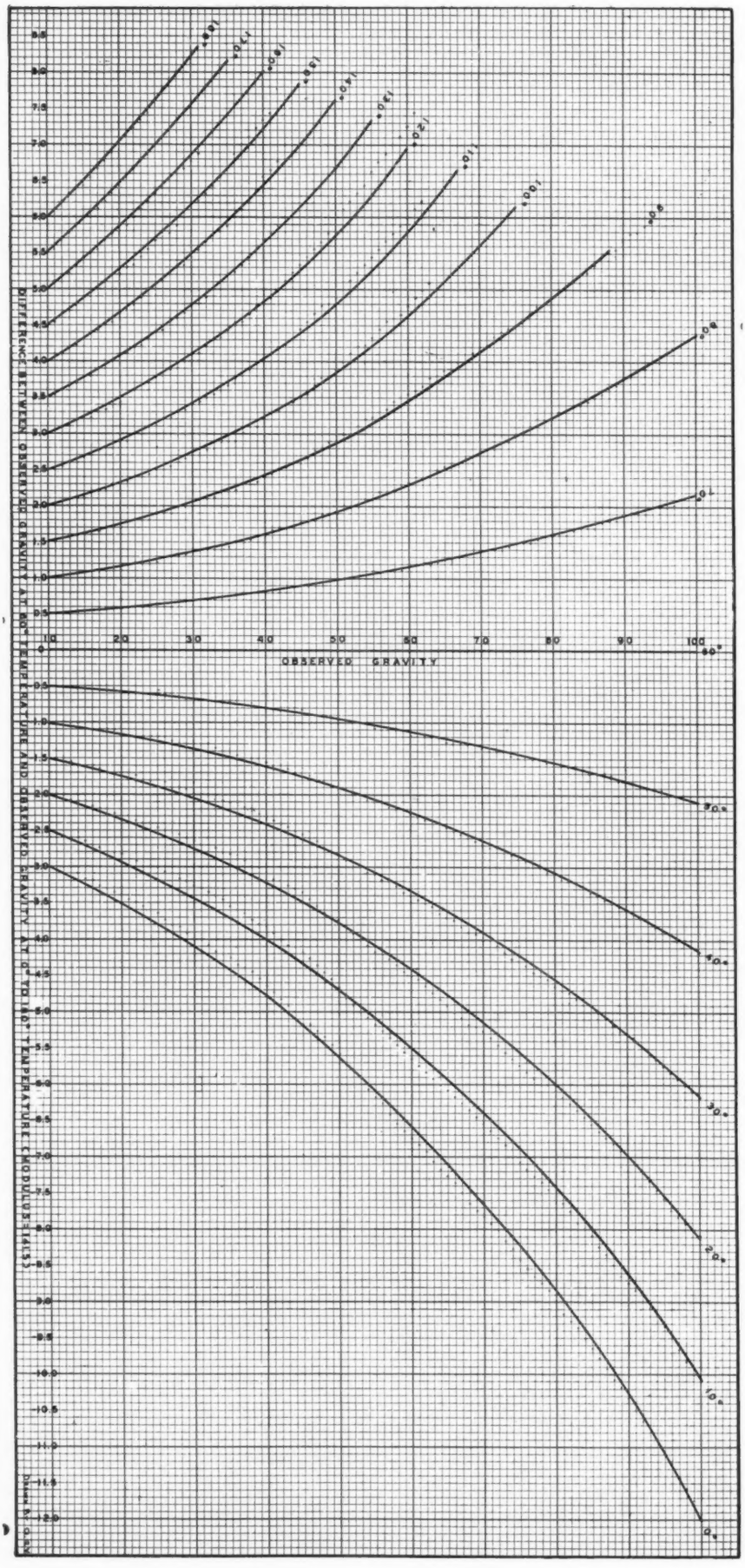


Table I

A. P. I. OBSERVED GRAVITY - TEMPERATURE (Modulus 141.5)

0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
7.00	7.50	8.00	8.50	9.00	9.50	10	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00
		9.00	9.50	10.00	10.50	11	11.50	12.00	12.50	13.00	13.50	14.00	14.55	15.10	15.55	16.11	16.55	17.11
		10.00	10.50	11.00	11.50	12	12.50	13.00	13.55	14.10	14.55	15.10	15.60	16.11	16.67	17.20	17.67	18.22
	10.40	10.91	11.45	12.00	12.50	13	13.50	14.00	14.60	15.10	15.60	16.11	16.67	17.20	17.70	18.22	18.78	19.33
10.90	11.40	11.90	12.40	13.00	13.50	14	14.50	15.10	15.60	16.10	16.60	17.20	17.70	18.22	18.78	19.33	19.89	20.40
11.82	12.36	12.90	13.40	13.91	14.50	15	15.50	16.10	16.60	17.11	17.67	18.20	18.78	19.33	19.89	20.44	21.00	21.44
12.80	13.30	13.82	14.40	14.90	15.50	16	16.55	17.10	17.60	18.20	18.70	19.22	19.80	20.40	20.90	21.50	22.00	22.55
13.73	14.27	14.80	15.36	15.90	16.50	17	17.60	18.10	18.66	19.20	19.78	20.30	20.89	21.44	22.00	22.55	23.11	23 67
14.70	15.20	15.80	16.30	16.90	17.50	18	18.60	19.10	19.70	20.22	20.80	21.33	21.90	22.50	23.11	23.67	24.22	24.78
15.64	16.20	16.73	17.30	17.90	18.45	19	19.60	20.10	20.70	21.30	21.80	22.40	23.00	23.55	24.20	24.78	25.33	25.89
16.60	17.18	17.70	18.30	18.90	19.40	20	20.60	21.11	21.70	22.30	22.89	23.44	24.10	24.67	25.22	25.80	26.44	27.00
17.54	18.10	18.70	19.30	19.82	20.40	21	21.60	22.20	22.78	23.33	23.90	24.55	25.11	25.70	26.30	26.89	27.55	28.11
18.50	19.09	19.64	20.27	20.80	21.40	22	22.60	23.20	23.80	24.40	25.00	25.60	26.20	26.78	27.33	28.00	28.67	29.22
19.45	20.00	20.60	21.20	21.80	22.40	23	23.60	24.20	24.80	25.40	26.00	26.67	27.22	27.89	28.44	29.11	29.78	30.33
20.40	21.00	21.60	22.20	22.80	23.40	24	24.60	25.20	25.80	26.44	27.10	27.70	28.33	29.00	29.55	30.22	30.89	31.44
21.36	22.00	22.54	23.20	23.80	24.40	25	25.60	26.22	26.89	27.50	28.11	28.78	29.40	30.00	30.67	31.33	32.00	32.63
22.27	22.91	23.50	24.18	24.80	25.40	26	26.60	27.30	27.90	28.50	29.20	29.80	30.44	31.11	31.70	32.44	33.11	33.78
23.20	23.90	24.50	25.10	25.73	26.40	27	27.60	28.30	28.90	29.55	30.22	30.89	31.55	32.22	32.78	33.55	34.22	34.89
24.18	24.82	25.45	26.10	26.70	27.36	28	28.67	29.30	30.00	30.60	31.30	31.90	32.60	33.30	33.89	34.60	35.33	36.00
25.09	25.80	26.40	27.09	27.70	28.30	29	29.70	30.33	31.00	31.66	32.33	33.00	33.67	34.33	35.00	35.67	36.44	37.11
26.00	26.73	27.36	28.00	28.70	29.30	30	30.70	31.40	32.00	32.70	33.40	34.10	34.78	35.44	36.11	36.78	37.55	38.22
27.00	27.70	28.30	29.00	29.70	30.30	31	31.70	32.40	33.10	33.70	34.44	35.11	35.80	36.55	37.22	37.89	38.67	
27.91	28.64	29.30	30.00	30.70	31.30	32	32.70	33.40	34.10	34.78	35.50	36.22	36.89	37.66	38.33			
28.82	29.60	30.27	31.00	31.64	32.30	33	33.70	34.40	35.11	35.80	36.55	37.30	38.00	38.78	39.43			
29.80	30.54	31.20	31.91	32.60	33.30	34	34.70	35.40	36.20	36.89	37.60	38.33	39.11	39.80	40.56			
30.73	31.45	32.18	32.90	33.60	34.30	35	35.70	36.44	37.20	37.90	38.67	39.44	40.20	40.89	41.67			
31.64	32.40	33.10	33.90	34.54	35.30	36	36.78	37.50	38.22	38.90	39.78	40.50	41.22	42.00	42.88			
32.60	33.36	34.09	34.82	35.50	36.30	37	37.80	38.50	39.30	40.00	40.80	41.55	42.33	43.11	44.00			
33.55	34.27	35.00	35.80	36.50	37.27	38	38.80	39.55	40.30	41.10	41.89	42.66	43.44	44.22	45.11			
34.45	35.20	36.00	36.73	37.50	38.20	39	39.80	40.60	41.33	42.10	43.00	43.78	44.55	45.38	46.22			
35.36	36.18	36.91	37.70	38.45	39.20	40	40.80	41.60	42.40	43.22	44.00	44.80	45.67	46.55	47.33			
36.27	37.09	37.82	38.64	39.40	40.20	41	41.80	42.67	43.44	44.30	45.11	45.89	46.78	47.66	48.44			
37.18	38.00	38.80	39.60	40.40	41.20	42	42.80	43.70	44.50	45.33	46.20	47.00	47.89	48.78				
38.09	38.91	39.73	40.54	41.36	42.20	43	43.80	44.70	45.55	46.40	47.22	48.11	49.00					
39.00	39.90	40.70	41.50	42.30	43.20	44	44.89	45.70	46.60	47.44	48.33	49.22						
39.82	40.82	41.64	42.45	43.30	44.18	45	45.90	46.78	47.60	48.50	49.44	50.33						
40.82	41.73	42.54	43.40	44.27	45.10	46	46.90	47.80	48.67	49.55	50.55	51.44						
41.73	42.64	43.45	44.36	45.20	46.10	47	47.90	48.80	49.78	50.67	51.67	52.56						
42.64	43.54	44.36	45.27	46.18	47.10	48	48.90	49.89	50.80	51.78	52.78	53.66						
43.54	44.45	45.30	46.20	47.10	48.09	49	50.00	50.90	51.89	52.80	53.80	54.78						
44.42	45.33	46.27	47.18	48.10	49.00	50	51.00	51.90	52.90	53.89	54.89	56.00						
45.27	46.18	47.18	48.09	48.91	50.00	51	52.00	53.00	54.00	55.00	56.00	57.11						
46.18	47.09	48.09	49.00	50.00	51.00	52	53.00	54.00	55.00	56.11	57.11	58.22						
47.08	48.00	49.00	50.00	51.00	52.00	53	54.00	55.00	56.11	57.20	58.22	59.33						
47.92	48.91	49.91	50.91	51.91	53.00	54	55.00	56.10	57.20	58.22	59.33	60.44						
48.82	49.82	50.82	51.90	52.90	53.91	55	56.10	57.11	58.22	59.33	60.44	61.63						
49.73	50.73	51.80	52.82	53.90	54.90	56	57.10	58.20	59.30	60.44	61.55	62.78						
50.58	51.64	52.73	53.80	54.82	55.90	57	58.10	59.20	60.33	61.55	62.67	63.89						
51.45	52.54	53.64	54.73	55.80	56.90	58	59.10	60.22	61.44	62.60	63.78	65.00						
52.36	53.45	54.54	55.64	56.80	57.90	59	60.11	61.30	62.50	63.66	64.89	66.11						
53.25	54.36	55.50	56.60	57.73	58.82	60	61.20	62.33	63.55	64.78	66.00	67.25						
54.17	55.27	56.45	57.54	58.70	59.80	61	62.20	63.40	64.60	65.89	67.11	68.44						
55.08	56.18	57.36	58.50	59.64	60.80	62	63.20	64.40	65.67	67.00	68.22							
55.92	57.09	58.27	59.45	60.60	61.80	63	64.20	65.44	66.78	68.10								
56.82	58.00	59.18	60.36	61.60	62.80	64	65.22	66.50	67.80									
57.73	58.91	60.09	61.30	62.54	63.73	65	66.30	67.55	68.89									
58.64	59.82	61.00	62.27	63.50	64.70	66	67.30	68.60	69.90									
59.50	60.73	61.91	63.18	64.45	65.70	67	68.30	69.60	71.00									
60.36	61.64	62.82	64.10	65.40	66.70	68	69.33	70.67	72.00									
61.27	62.54	63.80	65.09	66.36	67.70	69	70.40	71.70	73.11									
62.18	63.45	64.73	66.00	67.30	68.64	70	71.40	72.78	74.20									
63.09	64.36	65.64	67.00	68.27	69.60	71	72.40	73.80	75.22									
64.00	65.27	66.54	67.91	69.20	70.60	72	73.40	74.80	76.33									
64.83	66.17	67.45	68.82	70.20	71.60	73	74.40	75.89	77.40									
65.73	67.00	68.36	69.73	71.18	72.54	74	75.44	76.90	78.44									
66.58	67.91	69.27	70.70	72.10	73.50	75	76.50	78.00	79.50									
67.45	68.82	70.18	71.64	73.09	74.50	76	77.50	79.00	80.55									
68.36	69.73	71.09	72.54	74.00	75.50	77	78.50	80.11	81.67									
69.27	70.64	72.00	73.50	75.00	76.50	78	79.55	81.20	82.78									
70.17	71.54	73.00	74.45	75.91	77.45	79	80.60	82.20	83.80									
71.00	72.45	73.91	75.36	76.90	78.40	80	81.60	83.22	84.89									
71.83	73.36	74.82	76.30	77.82	79.40	81	82.60	84.30	86.00									
72.73	74.25	75.73	77.27	78.80	80.40	82	83.60	85.33	87.00									
73.64	75.09	76.64	78.18	79.80	81.40	83	84.67	86.40	88.11									
74.50	76.00	77.54	79.10	80.73	82.36	84	85.70	87.40	89.20									
75.36	76.91	78.45	80.09	81.64	83.30	85	86.70	88.44	90.22									
76.22	77.75	79.36	81.00	82.60	84.30	86	87.70	89.50	91.33									
77.08	78.64	80.27	81.91	83.54	85.30	87	88.78	90.55	92.44									
77.92	79.50	81.18	82.82	84.50	86.27	88	89.80	91.60	93.50									
78.82	80.36	82.09	83.73	85.45	87.20	89	90.80	92.67	94.55									
79.67	81.27	83.00	84.70	86.40	88.20	90	91.89	93.78	95.67									
80.50	82.17	83.91	85.64	87.36	89.18	91	92.90	94.80	96.78									
81.36	83.00	84.82	86.54	88.30	90.10	92	93.90	95.89	97.80									
82.25	83.91	85.67	87.45	89.27	91.10	93	94.90	96.90	98.89									
83.08	84.82	86.54	88.36	90.18	92.10	94	96.00	98.00										
83.92	85.67	87.42	89.27	91.10	93.09	95	97.00	99.00										
84.75	86.50	88.27	90.18	92.09	94.00	96	98.00											
85.58	87.33	89.18	91.09	93.00	95.00	97	99.11											
86.42	88.18	90.09	92.00	94.00	96.00	98												
87.25	89.09	91.00	92.91	94.91	97.00	99												
88.08	90.00	91.91	93.82	95.82	97.91	100												

O.G.V.



is taken from an A.P.I. gravity-temperature correction table.

By reading the observed gravity to the nearest 0.1 of a deg. and the temperature to the nearest deg., we may expect to obtain the corrected gravity at 60 deg. to within 0.1 deg., plus or minus, of what would be obtained were the oil brought to exactly 60-deg. temperature and the true gravity read direct, as is the custom in refinery laboratories.

A temperature-gravity graph is found to be useful and expedient in obtaining the true gravity of the oils by the dispatcher's department, also by the engineer in his computations of the capacity of the lines. Pipe line engineers in their pipe flow computations are interested only in the observed gravity at the actual temperature of the oil flowing in the lines. Using the corrected gravity at 60 deg. fahr., instead of the observed gravity at the actual temperature of the oil flowing in the pipe, may cause a considerable difference in the computed and the actual carrying capacity of the lines.

The conventional table that is used in converting observed gravity at a given temperature to the corrected gravity at 60 deg. fahr. is somewhat cumbersome in determining the observed gravity for a given temperature corresponding to a given corrected gravity at 60 deg. fahrenheit. This, however, is reduced to a very simple operation by use of the accompanying graph, Fig. 1, as will be explained later.

It may be interesting to those who may have use for the graph to know how the Master Graph, which includes gravities from 10 to 100 for a temperature range of 0 to 180 deg. was prepared from the A.P.I. gravity tables in the Tag Manual.

By interpolation, the observed gravities, Table 1, were determined for intervals of 10 deg. fahr. beginning at a temperature of 0 deg. and going to 180 degrees. The interpolation was taken to the nearest hundredth in order that the plotted points would be less zig-zag. It was hoped that straight lines or uniform slight curves averaging the plotted points would not give a variation of more than .05 plus or minus in any of the plotted points. This was found true except in a few instances, as shown in Table 3.

In order to verify the correct location of each line on the final Master Graph, from which the graph, Fig. 1, was taken, the values in Table 1 were

Fig. 2. Graphical representation of the data in Tables 1, 2, and 3

Table 2

OBSERVED GRAVITY - TEMPERATURE (Modulus 141.5)																			
0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	
7.00	7.50	8.00	8.50	9.00	9.50	10	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	15.50	16.00	
7.95	8.46	8.96	9.47	9.98	10.49	11	11.51	12.01	12.52	13.03	13.54	14.05	14.56	15.07	15.58	16.09	16.59	17.10	
8.90	9.41	9.93	10.45	10.97	11.48	12	12.52	13.03	13.55	14.06	14.58	15.09	15.61	16.13	16.65	17.17	17.68	18.20	
9.85	10.37	10.89	11.42	11.95	12.47	13	13.52	14.04	14.57	15.09	15.61	16.14	16.66	17.20	17.73	18.26	18.78	19.31	
10.80	11.33	11.86	12.40	12.93	13.46	14	14.53	15.06	15.60	16.12	16.65	17.19	17.72	18.26	18.80	19.34	19.88	20.41	
11.75	12.29	12.82	13.37	13.91	14.45	15	15.54	16.08	16.62	17.15	17.69	18.24	18.78	19.33	19.88	20.43	20.98	21.52	
12.70	13.24	13.79	14.35	14.90	15.45	16	16.55	17.10	17.64	18.18	18.73	19.29	19.84	20.40	20.96	21.52	22.08	22.62	
13.64	14.19	14.75	15.31	15.88	16.44	17	17.56	18.11	18.67	19.22	19.78	20.33	20.90	21.47	22.04	22.60	23.17	23.73	
14.59	15.14	15.72	16.30	16.87	17.43	18	18.57	19.13	19.70	20.25	20.82	21.39	21.96	22.54	23.12	23.69	24.27	24.84	
15.53	16.11	16.69	17.27	17.86	18.42	19	19.58	20.15	20.72	21.29	21.87	22.44	23.03	23.61	24.20	24.78	25.37	25.95	
16.48	17.06	17.65	18.25	18.84	19.42	20	20.59	21.17	21.75	22.32	22.92	23.50	24.09	24.68	25.28	25.87	26.47	27.06	
17.42	18.01	18.61	19.22	19.82	20.41	21	21.59	22.19	22.78	23.36	23.96	24.56	25.15	25.75	26.37	26.96	27.58	28.17	
18.37	18.96	19.57	20.19	20.80	21.40	22	22.60	23.21	23.81	24.40	25.01	25.61	26.22	26.83	27.45	28.06	28.68	29.28	
19.31	19.91	20.53	21.16	21.78	22.39	23	23.61	24.23	24.84	25.44	26.06	26.67	27.28	27.91	28.54	29.15	29.78	30.39	
20.25	20.86	21.49	22.13	22.76	23.38	24	24.62	25.25	25.87	26.48	27.11	27.73	28.35	28.99	29.63	30.25	30.89	31.51	
21.20	21.81	22.45	23.10	23.74	24.37	25	25.63	26.27	26.90	27.53	28.16	28.79	29.42	30.07	30.71	31.35	32.00	32.63	
22.13	22.76	23.41	24.07	24.71	25.36	26	26.64	27.29	27.93	28.56	29.21	29.85	30.49	31.15	31.80	32.45	33.11	33.75	
23.07	23.71	24.37	25.04	25.69	26.35	27	27.65	28.31	28.96	29.60	30.26	30.91	31.57	32.23	32.89	33.55	34.22	34.87	
24.02	24.66	25.33	26.01	26.68	27.34	28	28.67	29.34	30.00	30.65	31.32	31.98	32.64	33.31	33.99	34.65	35.33	35.99	
24.96	25.61	26.29	26.98	27.66	28.33	29	29.68	30.36	31.03	31.69	32.37	33.04	33.71	34.40	35.08	35.76	36.45	37.11	
25.89	26.56	27.24	27.94	28.63	29.32	30	30.69	31.38	32.07	32.74	33.43	34.11	34.79	35.49	36.18	36.87	37.56	38.24	
26.83	27.51	28.20	28.91	29.61	30.31	31	31.70	32.40	33.11	33.79	34.49	35.18	35.87	36.58	37.28	37.98	38.68	39.36	
27.77	28.45	29.16	29.88	30.59	31.30	32	32.71	33.42	34.14	34.84	35.56	36.26	36.96	37.67	38.38	39.09	39.80		
28.70	29.40	30.11	30.84	31.56	32.28	33	33.72	34.45	35.18	35.89	36.62	37.33	38.04	38.76	39.48	40.20	40.92		
29.63	30.34	31.07	31.81	32.54	33.27	34	34.73	35.47	36.21	36.94	37.68	38.40	39.12	39.85	40.58	41.31	42.04		
30.56	31.28	32.02	32.78	33.52	34.26	35	35.75	36.50	37.25	37.99	38.74	39.47	40.20	40.94	41.68	42.42	43.17		
31.49	32.22	32.98	33.74	34.49	35.25	36	36.76	37.52	38.28	39.03	39.79	40.54	41.29	42.04	42.79	43.54			
32.42	33.17	33.94	34.71	35.47	36.23	37	37.78	38.55	39.32	40.08	40.85	41.61	42.37	43.14	43.89	44.65			
33.35	34.11	34.89	35.67	36.44	37.22	38	38.79	39.57	40.35	41.12	41.90	42.68	43.45	44.23	44.99	45.76			
34.28	35.05	35.84	36.63	37.41	38.21	39	39.80	40.59	41.39	42.17	42.97	43.76	44.54	45.33	46.10	46.88			
35.21	36.00	36.79	37.59	38.38	39.20	40	40.81	41.62	42.43	43.23	44.04	44.84	45.64	46.44	47.22	48.01			
36.14	36.94	37.75	38.56	39.36	40.18	41	41.83	42.66	43.47	44.29	45.10	45.91	46.73	47.54	48.34				
37.06	37.87	38.69	39.51	40.33	41.17	42	42.84	43.69	44.52	45.35	46.17	46.99	47.82	48.64	49.46				
37.98	38.80	39.64	40.47	41.31	42.15	43	43.86	44.72	45.56	46.40	47.24	48.08	48.91	49.76	50.59				
38.90	39.73	40.58	41.43	42.28	43.14	44	44.98	45.75	46.60	47.46	48.32	49.18	50.02	50.87	51.72				
39.81	40.66	41.52	42.39	43.26	44.12	45	45.89	46.77	47.65	48.52	49.39	50.27	51.12	51.98	52.85				
40.72	41.59	42.46	43.35	44.23	45.11	46	46.90	47.80	48.69	49.58	50.47	51.36	52.23	53.10					
41.63	42.51	43.40	44.30	45.20	46.10	47	47.91	48.82	49.74	50.64	51.54	52.45	53.33	54.22					
42.54	43.43	44.34	45.26	46.17	47.08	48	48.93	49.85	50.79	51.70	52.62	53.54	54.44	55.34					
43.45	44.36	45.29	46.21	47.14	48.06	49	49.95	50.88	51.84	52.77	53.70	54.64	55.55	56.47					
44.36	45.29	46.23	47.17	48.10	49.04	50	50.97	51.92	52.89	53.84	54.79	55.74	56.67	57.61					
45.27	46.22	47.16	48.12	49.08	50.03	51	51.99	52.96	53.94	54.91	55.88	56.85	57.79						
46.18	47.15	48.10	49.07	50.04	51.01	52	53.01	54.00	54.99	55.98	56.97	57.95	58.92						
47.09	48.07	49.04	50.03	51.01	52.00	53	54.02	55.03	56.04	57.06	58.07	59.06	60.06						
48.00	48.99	49.98	50.98	51.97	52.98	54	55.04	56.06	57.09	58.13	59.17	60.18	61.20						
48.91	49.91	50.92	51.93	52.94	53.97	55	56.06	57.10	58.15	59.21	60.27	61.30	62.34						
49.81	50.83	51.85	52.88	53.91	54.95	56	57.08	58.14	59.21	60.29	61.37	62.42							
50.71	51.75	52.79	53.83	54.88	55.93	57	58.10	59.19	60.28	61.37	62.47	63.55							
51.61	52.67	53.72	54.78	55.84	56.91	58	59.12	60.23	61.34	62.45	63.57	64.68							
52.50	53.59	54.66	55.73	56.80	57.89	59	60.14	61.27	62.40	63.54	64.68	65.82							
53.40	54.50	55.59	56.68	57.76	58.87	60	61.16	62.31	63.46	64.63	65.79	66.96							
54.30	55.41	56.52	57.62	58.72	59.85	61	62.18	63.35	64.52	65.72	66.90								
55.20	56.33	57.45	58.57	59.69	60.83	62	63.20	64.39	65.58	66.81	68.01								
56.10	57.24	58.37	59.51	60.65	61.81	63	64.22	65.43	66.65	67.90	69.13								
57.00	58.15	59.30	60.46	61.61	62.79	64	65.24	66.48	67.72	69.00	70.25								
57.89	59.06	60.23	61.40	62.57	63.77	65	66.26	67.52	68.79	70.10	71.38								
58.78	59.97	61.16	62.34	63.53	64.75	66	67.29	68.56	69.86	71.20	72.51								
59.67	60.88	62.08	63.28	64.49	65.73	67	68.31	69.60	70.93	72.30	73.65								
60.56	61.79	63.00	64.22	65.45	66.71	68	69.33	70.65	72.00	73.40									
61.45	62.70	63.93	65.16	66.41	67.69	69	70.35	71.70	73.07	74.50									
62.35	63.61	64.85	66.10	67.36	68.67	70	71.37	72.74	74.14	75.60									
63.24	64.52	65.77	67.04	68.32	69.65	71	72.40	73.79	75.21	76.70									
64.13	65.42	66.69	67.98	69.27	70.62	72	73.42	74.84	76.29	77.80									
65.02	66.32	67.61	68.92	70.23	71.60	73	74.44	75.88	77.37	78.91									
65.90	67.22	68.53	69.86	71.19	72.58	74	75.47	76.92	78.44	80.02									
66.78	68.11	69.44	70.79	72.14	73.55	75	76.49	77.97	79.53	81.14									
67.66	69.00	70.35	71.73	73.10	74.53	76	77.51	79.02	80.60										
68.54	69.89	71.26	72.66	74.05	75.51	77	78.53	80.07	81.67										
69.41	70.78	72.18	73.59	75.01	76.49	78	79.56	81.12	82.74										
70.29	71.68	73.09	74.52	75.96	77.46	79	80.59	82.17	83.81										
71.16	72.58	74.00	75.45	76.91	78.44	80	81.61	83.22	84.88										
72.03	73.47	74.90	76.38	77.86	79.41	81	82.64	84.27	85.96										
72.89	74.35	75.80	77.31	78.82	80.39	82	83.67	85.33	87.04										
73.75	75.23	76.71	78.23	79.77	81.36	83	84.69	86.38	88.12										
74.61	76.11	77.62	79.17	80.72	82.33	84	85.71	87.44	89.20										
75.47	76.99	78.52	80.09	81.67	83.31	85	86.74	88.49	90.28										
76.33	77.87	79.42	81.01	82.62	84.28	86	87.77	89.55	91.37										
77.19	78.75	80.32	81.94	83.57	85.26	87	88.80	90.61	92.45										
78.04	79.62	81.22	82.86	84.52	86.23	88	89.82	91.67	93.54										
78.89	80.50	82.12	83.78	85.47	87.21	89	90.85	92.72											
79.74	81.37	83.02	84.70	86.42	88.18	90	91.88	93.78											
80.58	82.24	83.91	85.62	87.36	89.16	91	92.90	94.84											
81.41	83.11	84.81	86.54	88.31	90.13	92	93.93	95.89											
82.24	83.97	85.70	87.46	89.25	91.10	93	94.96	96.95											
83.07	84.83	86.59	88.38	90.20	92.07	94	95.99	98.00											
83.90	85.69	87.48	89.29	91.14	93.04	95	97.02	99.06											
84.73	86.55	88.37	90.20	92.09	94.02	96	98.05	100.12											
85.55	87.40	89.25	91.12	93.03	94.99	97	99.08	101.18											
86.36	88.24	90.13	92.03	93.98	95.96	98	100.10	102.24											
87.17	89.08	91.01	92.94	94.92	96.93	99	101.13	103.29											
87.98	89.92	91.89	93.85	95.86	97.90	100	102.16	104.36											O.G.V.

plotted vertically on a graph, Fig. 2, and the two graphs were carefully studied, keeping in mind the least possible variation in the final location of each line. The lines drawn through these plotted points, Fig. 2, were not straight lines, neither were they uniform slight curves, as it was logical to expect them to be. Then Table 2 was made to conform with the adjusted curve values, from which the final Master Graph was made.

This procedure of cross-plotting for determining the proper location of each gravity line, especially when made at the scale used, should give results that represent the probable values. There are some differences in the tabular values, Table 1, and the final curves adopted, as may be seen in Fig. 2, and also in Table 3; however, this difference is very slight within the range of temperatures and gravities most commonly met with, as will be mentioned later.

Experimental Gravity Values of Petroleum Oils For 10-deg. Temperature Intervals From 0 to 180 deg. Fahrenheit

Let us assume for the purpose of discussion that the tabular values in Table 1 are experimental values determined by an A.P.I. gravity hydrometer (Modulus 141.5) for intervals of 10 deg. fahrenheit. For example, an oil is cooled to a temperature of 0 deg. and the observed gravity is read as 33.55 A.P.I. degrees. The temperature of the sample is then raised at exactly 10-deg. intervals and the A.P.I. observed gravities and temperatures are read on the hydrometer. The following table gives the result.

Temp., deg. fahr.	Grav. deg. A.P.I.	Grav. Difference in deg.	Temp., deg. fahr.	Grav. deg. A.P.I.	Grav. Difference in deg.
0	33.55	—4.45	100	41.10	+3.10
10	34.27	—3.73	110	41.89	+3.89
20	35.00	—3.00	120	42.66	+4.66
30	35.80	—2.20	130	43.44	+5.44
40	36.50	—1.50	140	44.22	+6.22
50	37.27	—0.73	150	45.11	+7.11
60	38.00	0	160	45.76	+7.76
70	38.80	+0.80	170	46.50	+8.50
80	39.55	+1.55	180		
90	40.30	+2.30	190		

This sample of oil is found to be a 38.0-deg. A.P.I. gravity oil, for its observed A.P.I. gravity at a temperature of 60 deg. is 38.0 degrees. The gravity difference for each 10-deg. interval also is given as it is more suitable in plotting the experimental data.

Now let us assume that we have this same experimental data for a large collection of oils, both crude and refined, covering a range in true gravities from 10 deg. A.P.I. to 100 deg. A.P.I.

With such a fund of data at hand, the experimental points can be plotted on a graph similar to Fig. 2, and we may expect the plotted points for each temperature curve to appear to follow some form of a curve, and the temperature curves will appear to bear some relation to each other.

In establishing a curve for each temperature so that the curve will represent an average of all the plotted points, we would be reasonable in expecting the plotted points to follow some law of curvature such as a simple uniform curve, a parabola, etc., instead of a series of reverse curves of unknown curvature.

Thus the tabular values of Table 1, prepared from the A.P.I. Gravity Tables in the Tag Manual, were substituted for the experimental values and their values were plotted on the graph, Fig. 2 (dotted lines), and simple circular curves were found to represent best each temperature curve (solid lines).

Table 3

DIFFERENCE BETWEEN THE VANDERVEER AND A. P. I. OBSERVED GRAVITY TABLES

0	10	20	30	40	50	GRAVITY	70	80	90	100	110	120	130	140	150	160	170	180
.00	.00	.00	.00	.00	.00	10	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
		-.04	-.03	-.02	-.01	11	+.01	+.01	+.02	+.03	+.04	+.05	+.01	-.03	+.03	-.02	+.04	-.01
		-.07	-.05	-.03	-.02	12	+.02	+.03	.00	-.04	+.03	-.01	+.01	+.02	-.02	-.03	+.01	-.02
	-.03	-.02	-.03	-.06	-.03	13	+.02	+.04	-.03	-.01	+.01	+.03	-.01	.00	+.03	+.04	.00	-.02
-.10	-.07	-.04	.00	-.07	-.04	14	+.03	-.04	.00	+.02	+.05	-.01	+.02	+.04	+.02	+.01	-.01	+.01
-.07	-.07	-.08	-.03	.00	-.05	15	+.04	-.02	+.02	+.04	+.02	+.04	.00	.00	-.01	-.01	-.02	+.08
-.10	-.06	-.03	-.05	.00	-.05	16	.00	.00	+.04	-.02	+.03	+.07	+.04	.00	+.06	+.02	+.08	+.07
-.09	-.08	-.05	-.05	-.02	-.06	17	-.04	+.01	+.01	+.02	.00	+.03	+.01	+.03	+.04	+.05	+.06	+.06
-.11	-.06	-.08	.00	-.03	-.07	18	-.03	+.03	.00	+.03	+.02	+.06	+.06	+.04	+.01	+.02	+.05	+.06
-.11	-.09	-.04	-.03	-.04	-.03	19	-.02	+.05	+.02	-.01	+.07	+.04	+.03	+.06	.00	.00	+.04	+.06
-.12	-.12	-.05	-.05	-.06	+.02	20	-.01	+.06	+.05	+.02	+.03	+.06	-.01	+.01	+.06	+.07	+.03	+.06
-.12	-.09	-.09	-.08	.00	+.01	21	-.01	-.01	.00	+.03	+.06	+.01	+.04	+.05	+.07	+.07	+.03	+.06
-.13	-.13	-.07	-.08	.00	.00	22	.00	+.01	+.01	.00	+.01	+.01	+.02	+.05	+.12	+.06	+.01	+.06
-.14	-.09	-.07	-.04	-.02	-.01	23	+.01	+.03	+.04	+.04	+.06	.00	+.06	+.02	+.10	+.04	.00	+.06
-.15	-.14	-.11	-.07	-.04	-.02	24	+.02	+.05	+.07	+.04	+.01	+.03	+.02	-.01	+.08	+.03	.00	+.07
-.16	-.19	-.09	-.10	-.06	-.03	25	+.03	+.05	+.01	+.03	+.05	+.01	+.02	+.07	+.04	+.02	.00	.00
-.14	-.15	-.09	-.11	-.09	-.04	26	+.04	-.01	+.03	+.06	+.01	+.05	+.05	+.04	+.10	+.01	.00	-.03
-.13	-.19	-.13	-.06	-.04	-.05	27	+.05	+.01	+.06	+.05	+.04	+.02	+.02	+.01	+.11	.00	.00	-.02
-.16	-.16	-.12	-.09	-.02	-.02	28	.00	+.04	.00	+.05	+.02	+.08	+.04	+.01	+.10	+.05	.00	-.01
-.13	-.19	-.11	-.11	-.04	+.03	29	-.02	+.03	+.03	+.03	+.04	+.04	+.04	+.07	+.08	+.09	+.01	.00
-.11	-.17	-.12	-.06	-.07	+.02	30	-.01	-.02	+.07	+.04	+.03	+.01	+.01	+.05	+.07	+.09	+.01	+.02
-.17	-.19	-.10	-.09	-.09	+.01	31	.00	.00	+.01	+.09	+.05	+.07	+.07	+.03	+.06	+.09	+.01	
-.14	-.19	-.14	-.12	-.11	.00	32	+.01	+.02	+.04	+.06	+.06	+.04	+.07	+.01	+.05			
-.12	-.20	-.16	-.16	-.08	-.02	33	+.02	+.05	+.07	+.09	+.07	+.03	+.04	-.02	+.05			
-.17	-.20	-.13	-.10	-.06	-.03	34	+.03	+.07	+.01	+.05	+.08	+.07	+.01	+.05	+.02			
-.17	-.17	-.16	-.12	-.08	-.04	35	+.05	+.06	+.05	+.09	+.07	+.03	.00	+.05	+.01			
-.15	-.18	-.12	-.16	-.05	-.05	36	-.02	+.02	+.06	+.13	+.01	+.04	+.07	+.04	-.09			
-.18	-.19	-.15	-.11	-.03	-.07	37	-.02	+.05	+.02	+.08	+.05	+.06	+.04	+.03	-.11			
-.20	-.16	-.11	-.13	-.06	-.05	38	-.01	+.02	+.05	+.02	+.01	+.02	+.01	+.01	-.12			
-.17	-.15	-.16	-.10	-.09	+.01	39	.00	-.01	+.06	+.07	-.03	-.02	-.01	-.05	-.12			
-.15	-.18	-.12	-.11	-.07	.00	40	+.01	+.02	+.03	+.01	+.04	+.04	-.03	-.11	-.11			
-.13	-.15	-.07	-.08	-.04	-.02	41	+.03	-.01	+.03	-.01	-.01	+.02	-.05	-.12	-.10			
-.12	-.13	-.11	-.09	-.07	-.03	42	+.04	-.01	+.02	+.02	-.03	-.01	-.07	-.14				
-.11	-.11	-.09	-.07	-.05	-.05	43	+.06	+.02	+.01	.00	+.02	-.03	-.09					
-.10	-.13	-.12	-.07	-.02	-.06	44	-.01	+.05	.00	+.02	-.01	-.04						
-.01	-.16	-.12	-.06	-.04	-.06	45	-.01	-.01	+.05	+.02	-.05	-.06						
-.10	-.14	-.08	-.05	-.04	+.01	46	.00	.00	+.02	+.03	-.08	-.08						
-.10	-.13	-.05	-.06	.00	.00	47	+.01	+.02	-.04	-.03	-.13	-.11						
-.10	-.11	-.02	-.01	-.01	-.02	48	+.03	+.05	+.01	-.08	-.16	-.12						
-.09	-.09	-.01	+.01	+.04	-.03	49	-.05	-.02	-.05	-.03	-.10	-.14						
-.06	-.04	-.04	-.01	.00	+.04	50	-.03	+.02	-.01	-.05	-.10	-.26						
.00	+.04	-.02	+.03	+.17	+.03	51	-.01	-.04	-.06	-.09	-.12	-.26						
.00	+.06	+.01	+.07	+.04	+.01	52	+.01	.00	-.01	-.13	-.14	-.27						
+.01	+.07	+.04	+.03	+.01	.00	53	+.02	+.03	-.07	-.14	-.15	-.27						
+.08	+.08	+.07	+.07	+.06	-.08	54	+.04	-.04	-.11	-.09	-.16	-.26						
+.09	+.09	+.10	+.03	+.04	+.06	55	-.04	-.01	-.07	-.12	-.17	-.33						
+.08	+.10	+.05	+.06	+.01	+.05	56	-.02	-.06	-.09	-.15	-.18	-.36						
+.13	+.11	+.06	+.03	+.06	+.03	57	.00	-.01	-.05	-.18	-.20	-.34						
+.16	+.13	+.08	+.05	+.04	+.01	58	+.02	+.01	-.10	-.15	-.21	-.32						
+.14	+.14	+.12	+.09	.00	-.01	59	+.03	-.03	-.10	-.12	-.21	-.29						
+.15	+.14	+.09	+.08	+.03	+.05	60	-.04	-.02	-.09	-.15	-.21	-.29						
+.13	+.14	+.07	+.08	+.02	+.05	61	-.02	-.05	-.08	-.17	-.21							
+.12	+.15	+.09	+.07	+.05	+.03	62	.00	-.01	-.09	-.19	-.21							
+.18	+.15	+.10	+.06	+.05	+.01	63	+.02	-.01	-.13	-.20								
+.18	+.15	+.12	+.10	+.01	-.01	64	+.02	-.02	-.08									
+.16	+.15	+.14	+.10	+.03	+.04	65	-.04	-.03	-.10									
+.14	+.15	+.16	+.07	+.03	+.05	66	-.01	-.04	-.04									
+.17	+.15	+.17	+.10	+.04	+.03	67	+.01	.00	-.07									
+.20	+.15	+.18	+.12	+.05	+.01	68	.00	-.02	.00									
+.18	+.16	+.13	+.07	+.05	-.01	69	-.05	.00	-.04									
+.17	+.16	+.12	+.10	+.06	+.03	70	-.03	-.04	-.06									
+.15	+.16	+.13	+.04	+.05	+.05	71	.00	-.01	-.01									
+.13	+.15	+.15	+.07	+.07	+.02	72	+.02	+.04	-.04									
+.19	+.15	+.16	+.10	+.03	.00	73	+.04	-.01	-.03									
+.17	+.22	+.17	+.13	+.01	+.04	74	+.03	+.02	.00									
+.20	+.20	+.17	+.09	+.04	+.05	75	-.01	-.03	+.03									
+.21	+.18	+.17	+.09	+.01	+.03	76	+.01	+.02	+.05									
+.18	+.16	+.17	+.12	+.05	+.01	77	+.03	+.04	.00									
+.14	+.14	+.18	+.09	+.01	-.01	78	+.01	-.08	-.04									
+.12	+.14	+.09	+.07	+.05	+.01	79	-.01	-.03	+.01									
+.16	+.13	+.09	+.09	+.01	+.04	80	+.01	.00	-.01									
+.20	+.11	+.08	+.08	+.04	+.01	81	+.04	-.03	-.04									
+.16	+.10	+.07	+.04	+.02	-.01	82	+.07	.00	+.04									
+.11	+.14	+.07	+.05	-.03	-.04	83	+.02	-.02	+.01									
+.11	+.11	+.08	+.07	-.01	-.03	84	+.01	+.04	.00									
+.11	+.08	+.07	.00	+.03	+.01	85	+.04	+.05	+.06									
+.11	+.12	+.06	+.01	+.02	-.02	86	+.07	+.05	+.04									
+.11	+.11	+.05	+.03	+.03	-.04	87	+.02	+.06	+.01									
+.12	+.12	+.04	+.04	+.02	-.04	88	+.02	+.07	+.04									
+.07	+.14	+.03	+.05	+.02	+.01	89	+.05	+.05										
+.07	+.10	+.02	.00	+.02	-.02	90	-.01	.00										
+.08	+.07	.00	-.02	.00	-.02	91	.00	+.04										
+.05	+.11	-.01	.00	+.01	+.03	92	+.03	.00										
-.01	+.06	+.03	+.01	+.02	.00	93	+.06	+.05										
-.01	+.01	+.05	+.02	+.02	-.03	94	-.01	.00										
-.02	+.02	+.06	+.02	+.04	-.05	95	+.02	+.06										
-.02	+.05	+.10	+.02	.00	+.02	96	+.05											
-.03	+.07	+.07	+.03	+.03	-.01	97	-.03											
-.06	+.06	+.04	+.03	-.02	-.04	98												
-.07	-.01	+.01	+.03	+.01	-.07	99												
-.10	-.08	-.02	+.03	+.04	-.01	100												

O.G.V.

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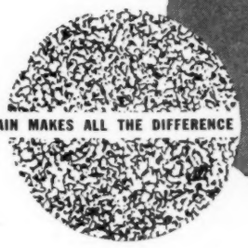
DUCTILOY

. . . a high-tensile, high-ductile steel with unusual properties of special interest to the

Petroleum Industry



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DUCTILOY, National Steel's High Tensile Alloy, is a superior product with unusual possibilities for use in the petroleum industry.

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DUCTILOY can be used to increase strength, to give greater durability to equipment, and consequently to effect important operating economies.

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Although there is some variation in the plotted points and the lines used to represent them, the difference is very little, if any, for the range of temperatures and gravities most usually met with in pipe line practice; and for the other temperatures and gravities, the refiner would bring the temperature of his run sample to exactly 60 deg. fahr. and then read the true gravity direct, as the writer understands is the customary practice of the refiner for determining the gravity of all purchased oil.

The final graph, referred to as the Master Graph, is a drawing 22 in. by 101 inches. This drawing includes temperatures from 0 to 180 deg. fahr. and gravities from 10 to 100 (Modulus 141.5). In preparing working graphs from the Master Graph for any desired oil, similar to Fig. 1, about 15 gravity lines and 80 temperature lines are shown.[a]

Gravity Determinations By Use of Graph

Using the graph, Fig. 1, in connection with the following explanation as to the use of the temperature-gravity graph it is seen how much easier and quicker it is to determine the results than when the A.P.I. gravity tables are used.

For determining the computed or true gravity at 60 deg. fahr. for a given observed gravity and temperature, enter the graph at the bottom at the "observed gravity" reading, then follow this line up the graph to its intersection with the corresponding observed temperature, then read the corrected gravity on the diagonal line.

(a) Such graphs as these may be had to fit your particular needs in planographic sheets at a nominal price, by addressing A. E. Steel, 4827 East 7th Street, Kansas City, Missouri.

When the observed gravity and temperature is known for a certain oil and it is desired to know what the observed gravity will be when the oil is at another temperature, simply enter the graph at the bottom for the known observed gravity, then proceed up the graph to the intersection with its corresponding temperature, then follow the diagonal line to its intersection with the required temperature, then follow the vertical line down to the bottom where the required observed gravity is read.

For determining the observed gravity for a given temperature corresponding to a given corrected gravity at 60 deg. fahr., enter the graph at the top at the "true gravity" reading, then follow this diagonal line down the graph to its intersection with the given temperature, then follow the vertical line down to the bottom where the required gravity is read.

Practices and Methods of Preventing and Treating Crude-Oil Emulsions

THE petroleum industry has made outstanding advancements in developing new and improving old methods of handling "cut" or emulsified oil at minimum cost, states the U. S. Bureau of Mines, in a detailed report just published, which describes practical methods of preventing the formation of emulsions in oil-producing operations, modern practices of economically dehydrating crude-oil emulsions, and recent advances in emulsion-treating technique.

Emulsions of water and oil always have constituted one of the most serious forms of waste in the oil fields, and the dehydration of emulsified crude petroleum to obtain marketable or pipeline oil continues to confront operators in many areas. Within the last decade substantial improvements have been made in methods of resolving petroleum emulsions, and the present bulletin, written by G. B. Shea, brings up-to-date the technique of coping with the emulsion problem, previously reported in Bulletin 250, "Oil Field Emulsions," by D. B. Dow, published by the U. S. Bureau of Mines in 1926.

In recent years there has been a growing realization of the importance of emulsion-preventive measures leading to a more critical examination of the causes and sources of emulsions and methods of eliminating, or at least reducing, the degree of emulsification.

The bulletin discusses various preventive and remedial measures by which emulsification may be minimized or avoided entirely during the producing and gathering of crude oil. In attacking an emulsion problem with the view of reducing treating costs, the method of sampling is of primary importance in determining sources of emulsification, and the author has devoted a section of his bulletin to methods of sampling that eliminate emulsification in this operation, thereby assuring samples that are representative of the fluid in the system.

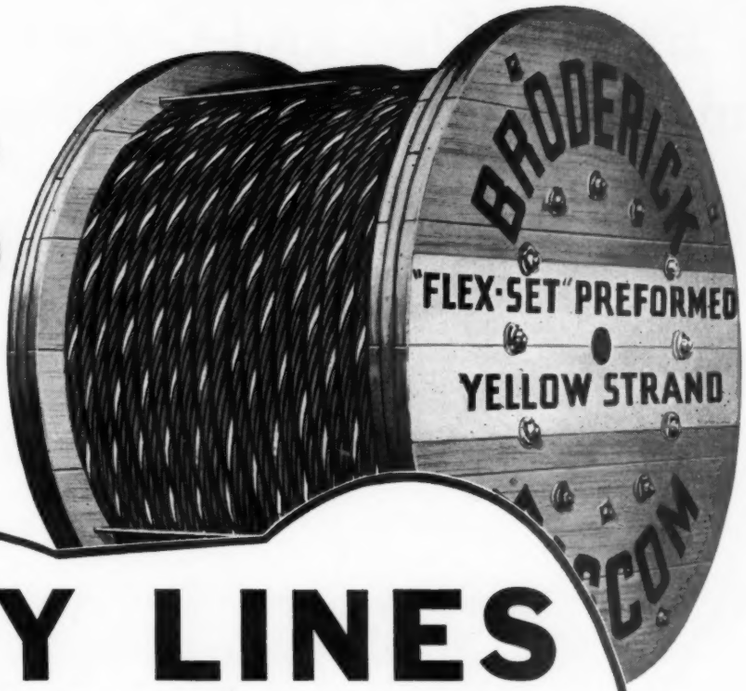
The batch and flow-line systems of chemical dehydration processes are discussed in detail with reference both to methods and equipment. A section dealing with treating temperatures and their effect on treating losses and the quantity of chemical used shows the saving that may be effected by reducing operating temperatures and increasing the quantity of chemical. The importance of properly handling and separating gas from "cut" oil in both chemical and electrical dehydration also is discussed.

The report contains a section on "down-the-hole" treating. On many properties this method is more effective and more economical than chemical treating at the surface after the "cut" oil has been discharged from the well. Emulsions that are only partly susceptible to treating chemicals in flow-line or batch processes often respond readily when the chemical is injected into the well or "down the hole."

The different types of electric dehydrators and the design and operation of the three general types of electric dehydrating plants (namely, batch, flow-line, and gravity-flow) are discussed. The bulletin also discusses treating costs, treating organization, and personnel. Developments in testing "cut" oil are discussed briefly.

U. S. Bureau of Mines Bulletin 417, "Practices and Methods of Preventing and Treating Crude Oil Emulsions," by G. B. Shea, may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., price 30 cents.

"FLEX-SET" PREFORMED YELLOW STRAND



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Made of special wire, drawn to our own exacting specifications by wire drawers who make nothing but wire, just as we have made nothing but wire rope for 63 solid years —

Wires and strands shaped to a permanently helical form before the rope is made up —

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Proper Use and Care of Safety Equipment Essential in Cleaning Storage Tanks

Gas indicators and masks or respirators provide complete protection from gas hazards when used and maintained properly

By F. RUTLEDGE DAVIS, President
Davis Emergency Equipment Company

WORKMEN engaged in cleaning petroleum storage tanks must be protected from numerous hazards, including fire or explosion and asphyxiation caused by gases or a deficiency of oxygen. To provide this protection, several types of safety appliances are required and, as the failure or misuse of any of these safeguards may have disastrous consequences, the proper use and care of this equipment is a matter of the greatest importance.

Protection From Fire and Explosion

For most petroleum vapors, the lower explosive limit is about 1 percent and the upper explosive limit is about 6 percent. Any mixture of these vapors and air having a vapor concentration within these limits will explode if ignited by a flame or spark. Mixtures that are either leaner or richer than those within the explosive range are non-explosive, but the richer mixtures will burn if diluted with air.

As a practicable safety standard, any atmosphere is considered dangerous with respect to fire and explosion if its petroleum vapor content is greater than 0.2 percent, or 20 percent of the lower explosive limit of the vapor; and no work that involves heat or flame or that is likely to produce electrical or mechanical sparks may be conducted in or around a tank until its internal atmosphere has been diluted by ventilation below this point, according to the regulations of the *Manual on Cleaning Petroleum Tanks* issued by the American Petroleum Institute.

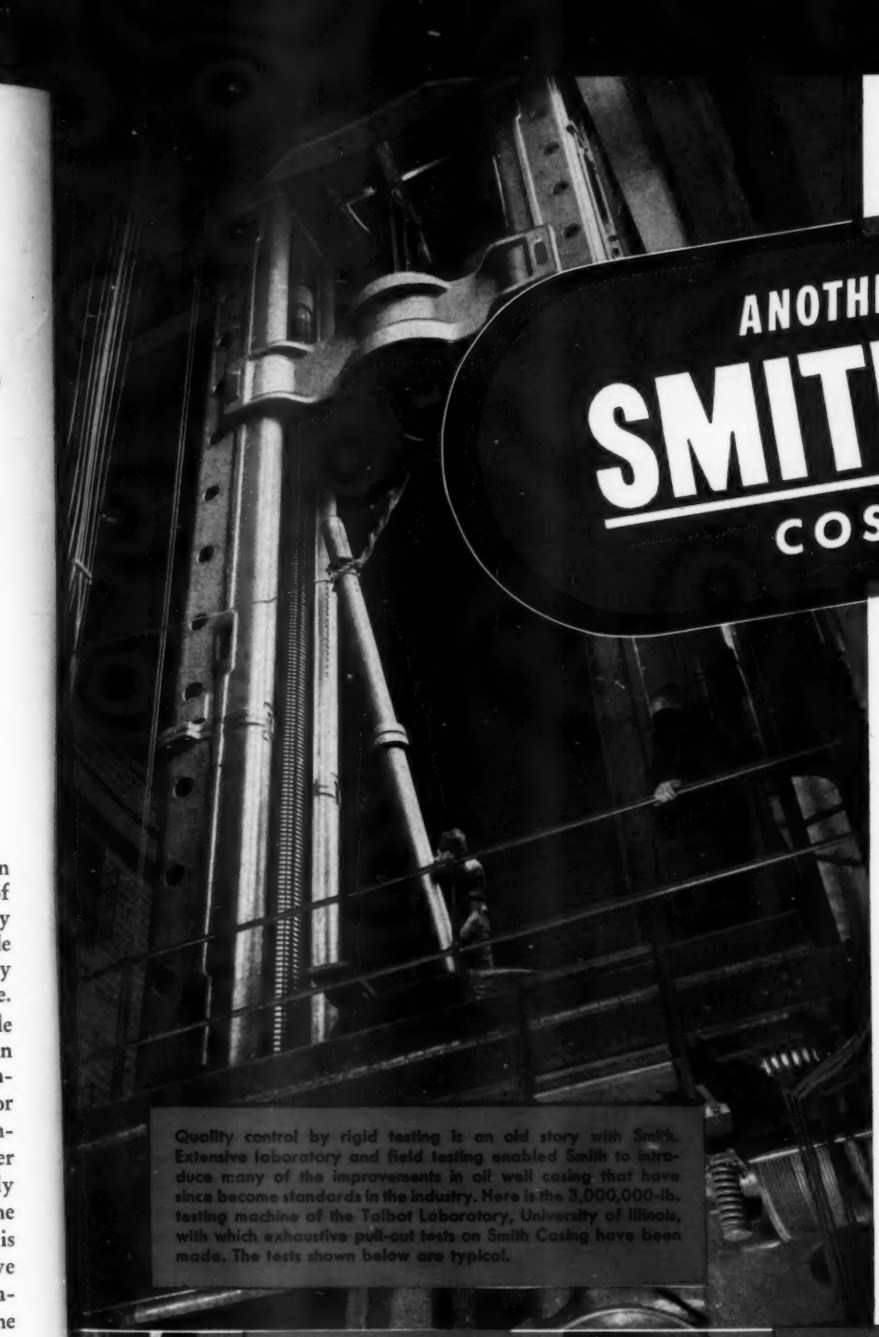
The Combustible Gas Indicator. Several types of instruments may be used for testing tank atmospheres. One commonly employed for this purpose is the combustible gas indicator. The practical advantages of the indicator include the following: it can be operated by workmen who do not have technical training; it is light, compact, and easily portable; it gives a reading in a few seconds and reads directly in terms of the lower explosive limit of the vapor-air mixture being tested; any desired number of readings can be made in rapid succession, and it can be safely used even in an explosive atmosphere.

F. RUTLEDGE DAVIS

has been engaged in the design and manufacture of first-aid equipment for 25 years and is responsible for many improvements in first-aid and safety equipment that are now accepted standards—His contributions include: the development of the interchangeable unit system of first-aid dressings and treatments; the formulation of a practical first-aid tannic-acid treatment for burns, and many improvements in gas masks and the blowers supplying air to hose masks —During the World War, Davis served on the War Service Committee connected with the surgical dressing industry, and he is a captain in the Chemical Warfare Reserve Corps, U. S. Army.

To operate the indicator, a sample of the atmosphere to be tested is drawn into the instrument through a sampling hose by means of an aspirator bulb or small hand pump. If the sample contains a flammable vapor, a meter mounted on the indicator immediately gives a reading showing whether the flammable vapor concentration is greater or less than the lower explosive limit and, if less, the vapor concentration is given in percentages of the lower explosive limit. If concentration is greater than the upper explosive limit, the meter needle swings as far as possible to the right and then drops back. It is, therefore, easy by using this instrument to check the effect of ventilation or to safeguard workmen inside a tank from an increase in vapor concentration, which may be due to leakage from another tank or to vapors given off by sediment, sludge, or scale. When workmen require this protection, readings should be made at least every 15 minutes; more frequently is often desirable.

The most satisfactory way to test the vapor conditions inside a large tank is by "coring"; that is, by making tests at 5-ft. levels throughout the tank. This is done by using a sampling hose that is sufficiently long to reach from the top to the bottom of the tank and is marked off in 5-ft. lengths. The hose is inserted in an opening at the top of the tank and tests are made at each level. If the tester may be exposed to



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Quality control by rigid testing is an old story with Smith. Extensive laboratory and field testing enabled Smith to introduce many of the improvements in oil well casing that have since become standards in the industry. Here is the 3,000,000-lb. testing machine of the Talbot Laboratory, University of Illinois, with which exhaustive pull-out tests on Smith Casing have been made. The tests shown below are typical.

Greater Pull-out Strength

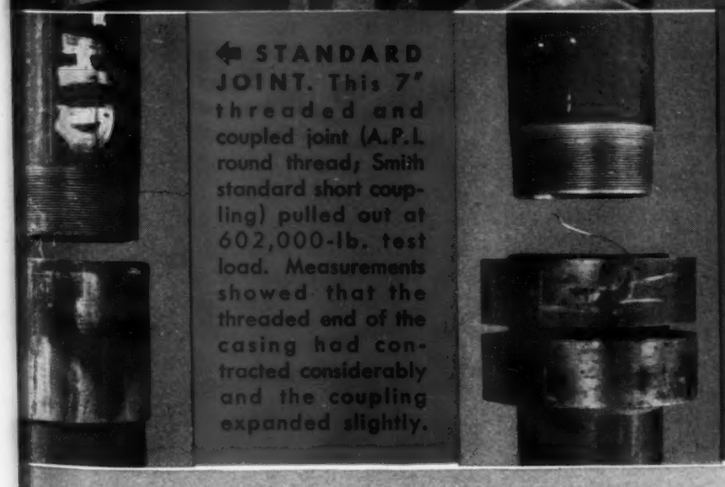
Smith Casing has long been recognized for its greater resistance to collapse without increase in weight.

Pull-out tests have proved that the same properties which increase collapse resistance also are responsible for material increase in pull-out strength.

If holes were cased with silver dollars—you wouldn't use two where one would do. Figuratively speaking, holes ARE cased with dollars—YOUR dollars—so it pays to use the stronger Smith Casing.

A technically informed Smith representative is within a few hours of your office. He can prove to you that Smith Casing reduces the amount of overhead that goes underground. Consult A. O. Smith Corporation, Milwaukee, Wisconsin. Offices at: New York, Pittsburgh, Chicago, Tulsa, Dallas, Shreveport, Houston, Corpus Christi, Los Angeles.

SMITH CASING



STANDARD JOINT. This 7" threaded and coupled joint (A.P.I. round thread; Smith standard short coupling) pulled out at 602,000-lb. test load. Measurements showed that the threaded end of the casing had contracted considerably and the coupling expanded slightly.

UNYIELDING COUPLING. Identical joint, but with coupling reinforced to prevent any circumferential stretching. In this test, the casing end was compressed sufficiently to pull out. It required a 662,000-pound test load.

UNYIELDING CASING END. Identical joint, but fitted with internal plug to prevent circumferential compressing of casing end. In this test, break-off at the roots of the thread occurred at 706,000-pound test load.

A.O.SMITH

CORPORATION

Milwaukee, Wisconsin

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vapors issuing from the tank, he should be protected by a gas mask.

When using a long sampling hose, care must be taken to procure an actual sample of the atmosphere to be tested to avoid merely testing a mixture left in the hose from a previous test. It requires about one squeeze of the aspirator bulb per foot of hose to draw a sample into the instrument so that, when using a 30-ft. hose, the bulb must be squeezed at least 30 times before the test is made.

When using the indicator, the operating voltage should be checked frequently and maintained at the proper value by means of the rheostat mounted on the instrument.

In testing vapors containing hydrogen sulphide, it is important to use an indicator designed to withstand the action of this gas. Otherwise, the sulphur in the gas may "poison" certain of the working parts and cause inaccurate readings.

Protection From Asphyxiation

All petroleum vapors are toxic and will produce unconsciousness or even death if breathed for any length of time in even small concentrations. The standard rule of the petroleum industry is that atmospheres containing more than 0.2 percent of petroleum vapor must not be entered by workmen without suitable respiratory protection. This danger point is the same as the one already noted, in the case of petroleum vapors, so that an atmosphere that is dangerous with respect to the fire hazard is also dangerous to breathe.

Hydrogen sulphide, a gas frequently encountered in the petroleum industry, is far more poisonous than any petroleum vapor. Breathing air containing 0.1 percent hydrogen sulphide may cause death, and when breathed in high concentrations it kills instantly. The maximum concentration that can be safely breathed without suitable protection is set at 0.01 percent but, as a rule, chemical filter respirators (gas masks) are worn whenever its characteristic odor gives warning of its presence.

Respiratory Protection. Workmen engaged in cleaning storage tanks commonly wear one of two types of respirators, or gas masks: the supplied-air respirator, known as the hose mask or fresh-air mask, and the chemical filter respirator, also called the canister-type gas mask.

Only the hose mask should be worn by men working inside storage tanks, especially when there is possibility of additional vapors from sediment or other sources. In this type of mask, fresh air is pumped to the wearer from a pure source through a hose and by means of a hand-operated or motor-operated blower. Thus it can be worn in any concentration of petroleum vapors or in atmospheres deficient in oxygen.

When a workman wearing a hose mask enters a confined space, he should always wear a safety belt or harness having a life-line attached and should always be kept under observation.

Blowers used in connection with hose masks preferably should be of the positive-pressure type because this type can maintain a positive pressure in the breathing circuit at all times and thus prevent the entrance of contaminated air through unsuspected leaks should the wearer of the mask be engaged in heavy work and make excessive demands on his air supply. Positive-pressure blowers are particularly indicated for hose lengths of 75 ft. or more.

A hose for use with a hose mask should be strong enough mechanically that no accident to it, or to the wearer of the mask, will rupture or crush it and cut off the air supply. Special attention should be given to the couplings attaching the hose to the mask and joining the several lengths of the hose together to make certain that they will not part under any pull to which they may be subjected. The hose itself and the couplings should be sufficiently strong so that if the life line is fouled the hose may be used to pull a man out of the tank. The surface of the hose should be smooth so that it will not tend to catch on obstructions. Should the outer covering be so worn that the metallic reinforcement is exposed, the hose should be discarded.

The chemical filter respirator (canister-type gas mask) is, in general, worn by men working in the open air around manheads and other tank openings. When this type of mask is used, the wearer draws air for breathing from the contaminated atmosphere around him through a canister containing chemicals that purify the air for his use. Canisters affording protection against various types of gases are identified by their colors. Thus, the canister for absorbing petroleum vapors only, is black; that for hydrogen sulphide only, is white; and that for both petroleum vapors and hydrogen sulphide is yellow.

In using canister-type gas masks, the following limitations must be considered:

1. They cannot be used in atmospheres containing more than 2 percent petroleum vapors or more than 1 percent hydrogen sulphide.
2. They cannot be used in atmospheres deficient in oxygen, as the wearer depends upon the surrounding atmosphere for his oxygen supply.
3. In rich mixtures, the canisters are rapidly depleted and have to be renewed if work is continued over a long period of time.

Before putting on a mask of any type, the wearer should examine it for defects and loose connections. After putting it on, he should test it for tightness by closing off the inlet from the canister and inhaling strongly. If the face piece collapses, the mask can be considered tight.

After the mask has been worn, it should be cleaned and sterilized before being placed in storage.

Masks are best stored in separate containers, preferably in cool, dark places, and never in close proximity to steam pipes. A good mask, given proper care, should have several years of service life.

Canisters. Canisters as they are received (sealed) from the manufacturer, will last about two years without serious deterioration if kept at an even temperature in air having a relative humidity of 40 to 60 percent.

Canisters that have been used but not exhausted can be used again if their openings are tightly closed and they are stored under proper conditions. A record should be kept of the time that each canister has been used, to give an approximate idea of its remaining life. In any case, however, a person using an old canister should enter the contaminated atmosphere cautiously so that he will have ample warning if his canister has become useless.

Resuscitation. Whenever workmen are likely to be exposed to noxious gases, it is most important that some, if not all, of them should be capable of applying the Schaefer prone-pressure method of artificial respiration. By the prompt and proper application of this treatment the lives of victims of even severe cases of gas poisoning can often be saved.

A valuable auxiliary in the treatment of gas-poisoning cases is the inhalator, an instrument for administering to the victim oxygen containing 5 to 7 percent carbon dioxide. The carbon dioxide in this mixture stimulates respiration and the oxygen provides a much more effective restorative than ordinary air. The timely use of this instrument, plus artificial respiration when breathing has ceased, has saved many thousands of lives.

New Pocket Transit Combines Functions of Several Instruments

Light-weight instrument is for use of engineers and geologists doing reconnaissance work—serves as compass, transit, level, clinometer, sextant, and alidade

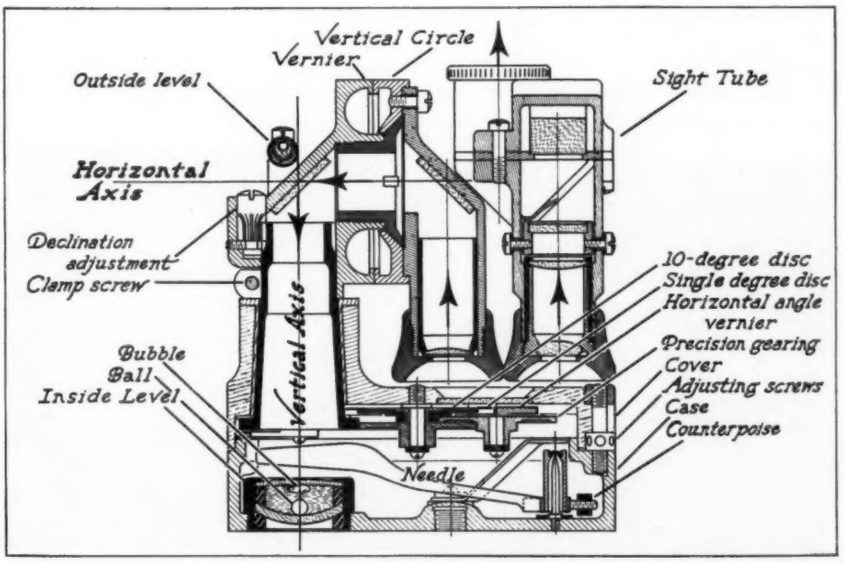
A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By LEW SUVERKROP
Petroleum Engineer and Geologist

IN the half-century since the conventional pocket transit was patented there have been many changes in the scope and nature of the work of engineers and geologists in which such a portable instrument is useful. Many recent developments (such as the use of aerial photographic maps, surveys in geophysical prospecting, etc.) have resulted in a desire for an instrument possessing the same element of portability, at the same time providing a wider range of usefulness. This article describes a new instrument resulting from 14 years' experiment and development that performs the functions of a compass, transit, level, hand-level, clinometer, Abney level, bubble sextant, and plane-table alidade. It is called the "Suverkrop Transit."

Compasses heretofore have consisted of a sight fixed to a case in which a magnetic needle is free to turn through 360°. In such instruments means are provided for reading the angle turned by the needle. They are calibrated so that the angle made by the needle is zero when the sight is directed to the north. The magnetic azimuth of a course through the sight of such an instrument is the angle turned by the resting needle from zero. The new instrument embodies a different principle. The case is not fixed to the sight, but may be rotated. Means are provided for reading the angle turned by the case. The instrument is calibrated so that the angle reads zero when the sight is directed to the north and the free needle coincides with an index within its case. The magnetic azimuth of a course through the sight of the new instrument is the angle necessary to turn the case in order to bring the resting needle to the index. In its essentials, the instrument consists of three parts: (1) a trough compass that may be provided with a level, (2) a sight rotatably attached to the trough compass, and (3) means of measuring, with respect to the axis of the trough compass through the index, the rotation of the sight.

Construction of the instrument is such that a 3-power telescopic sight is provided with which the object is viewed by the observer's right eye. With his left eye at the other eye-piece the observer simultaneously obtains a view of the magnetic needle and the level in the compass trough or "case" of the instrument. This is revealed by an accompanying illustration that shows a full-size cross-section of the instrument when folded. It will be noted that light entering the bottom of the case is transmitted upward (along the vertical axis) through the transparent inside level, passes the end of the compass needle, and is then transmitted (via the horizontal axis) through two mirrors into the eye of the observer. The impression given the observer from these two individual views is that of a single view in which he sees the distant object intersected by cross-hairs and overlain but not obscured by a clear view of needle and level. Simultane-



Cross-section of instrument when closed. The arrows indicate the lines of sight from each of the observer's eyes when the instrument is open and in use

LEW SUVERKROP

has an E.M. from Michigan School of Mines—Prior to becoming associated with the petroleum industry in 1921 he was a mining and mechanical engineer and at one time was with the U. S. Army Engineers—He helped develop and use sound ranging equipment for locating enemy artillery, the apparatus from which our present-day seismograph was derived—From 1921 to 1924 he was with the U. S. Bureau of Mines Petroleum Division, later taken over by U.S.G.S.—He was inspector with the California State Division of Oil and Gas, 1924-1925—Since 1925 he has been a consulting engineer and geologist, making his headquarters in Bakersfield California.

The instrument open for use

ous viewing of object, cross-hairs, needle, and level therefore is automatic. This is largely responsible for the accuracy and rapidity with which magnetic azimuth may be determined by use of the new instrument.

The two viewing tubes (sight and "level tube"), fitted with eye-pieces, rotate as a unit about the horizontal axis. A vertical circle and vernier are provided with which the vertical angle may be determined to ten minutes of arc. One of the two milled-head screws on the head of the instrument is for clamping against movement about the horizontal axis. The other is for the vertical axis. It will be apparent from the construction that vertical and horizontal angles are determined in one observation.

In performing work for which such an instrument ordinarily is used, horizontal angles are usually of most importance. A unique device permits easy reading of these horizontal angles. Two concentric disks (one divided in tens of deg. and the other in single deg.) are rotated by a simple train of gears, driven by the hollow column, which is free to rotate in the instrument case. This construction results in degree-divisions having a spacing equivalent to those of a circle several times the maximum dimension of the entire instrument. A vernier is provided reading direct to ten minutes of arc. The accuracy of the gearing is consistent with the accuracy of the reading indicated.

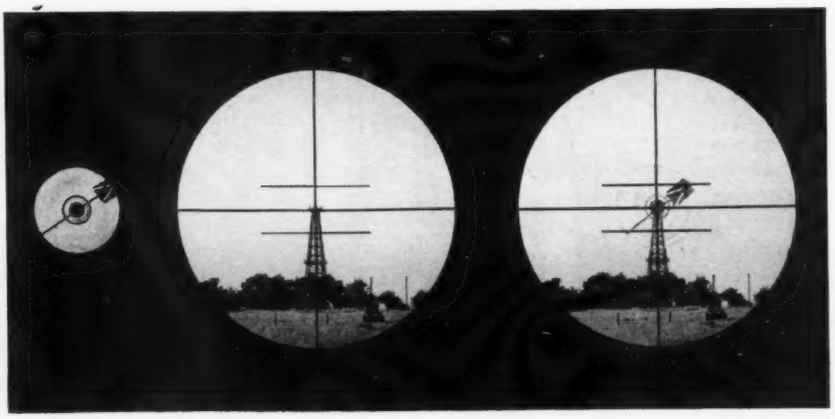
The compass needle is new in design. It is supported near one end, thus the accuracy of the needle is approximately that of an ordinary compass twice the greatest dimension of the entire instrument. The effective accuracy is actually much greater because of the design of the index used for determining when the needle is in the axis of the case, and because the needle is viewed under a magnifying glass. The needle has a low center of gravity, is provided with counterbalance, and is effectively air-damped by being made thin and wide.

The circular level within the case is unusual, it being provided with two moving elements (a bubble and a ball), which operate on surfaces of different radii of curvature. The ball indicates approximate level whereas more exact indications of level are obtained by use of the bubble. As swinging the vertical axis causes bubble and ball to move in opposite directions, the direction in which the axis must be moved to be made plumb is more readily noted. The construction gives, in small space, a combination of a "quick" and a rather precise level, facilitating the prompt and accurate plumbing of the instrument.

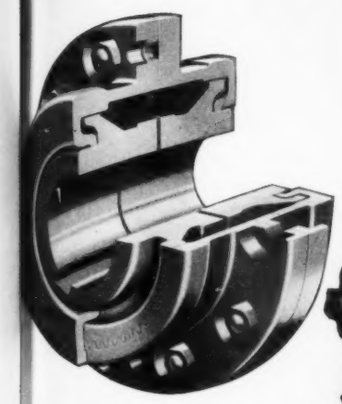
When used as a hand (Locke's) level or as an Abney level, the inside level is observed but the needle, of course, may be disregarded. For other purposes, including the adjustment of the instrument, an outside level is provided, mounted on the head of the instrument. Magnetic declination of any locality may be readily set-off on the instrument. This is done by means of a toothed pinion, provided with screw-slot, in the head of the instrument. This pinion engages with the toothed upper end of the hollow vertical spindle of the instrument. Once the declination is set off, the head is clamped tightly to the spindle.

The instrument is conveniently carried in its folded form in a leather case attached to the belt. To open the instrument for use, the sight tube is moved to the right until the distance between the eye pieces suits the observer's eyes and then the vertical circle is turned about the horizontal axis.

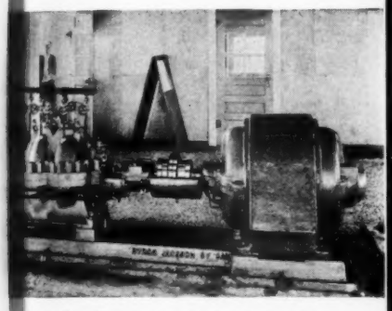
One reason for the accuracy of magnetic readings made with this instrument is the fact that the observer is not concerned with reading angles while making the observation itself. Angles are read after making the observation. This reduces the elements requiring attention during the observation and eliminates the possibility of "fudging" angles, as when checking an observation along a given course. When taking a sight for magnetic azimuth, the case is held in the left hand. The right hand holds the sight tube and directs it toward the object. The cross hairs are centered on the object and are kept centered on it during the entire observation. The case is free to rotate about both vertical and horizontal axes of the instrument. The instrument is leveled by (1) swinging the case, with respect to the sight tube, about the horizontal axis, and (2) rotating the entire instrument, as a unit, about the axis of the line of sight. When the level indicates that the vertical axis is



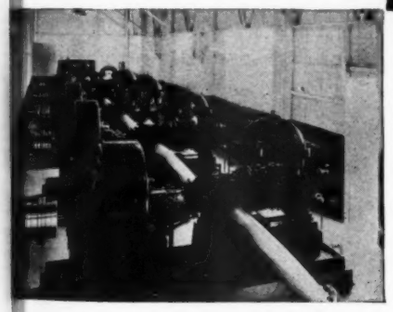
The view at the left is obtained through the left eye-piece when the instrument is plumb and the needle is at the target. The center view is obtained through the right eye-piece when the cross hairs are centered on an object. The view at the right is the impression given the observer resulting from the individual views of left and right eyes obtained simultaneously



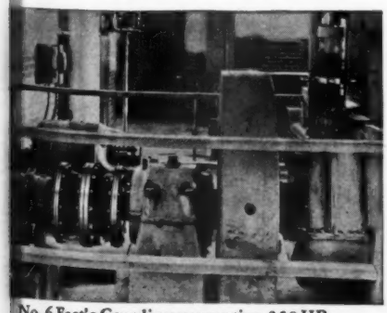
This illustration shows Fast's construction. The load-carrying surfaces are protected from wear by a positive film of oil. This oil is kept permanently clean by the rocking bearings, which make precise metal-to-metal contact forming permanent dust and moisture-proof seals. There are no perishable parts, grids, laminated plates or laminated pins . . . nothing to wear out . . . nothing to need attention other than oiling.



Fast's Coupling on pump, Oklahoma Pipe Line Co., Maud, Okla.



Fast's Standard and Floating Shaft Couplings, Great Lakes Pipe Line Co., Station 15, Roland, Iowa.



No. 6 Fast's Coupling connecting 350 HP, 270 rpm Winton Diesel Engine to Prescott Pump, Great Lakes Pipe Line Co., Barnsdall, Okla.

Fast's Couplings connecting 250/500 HP, 3550 rpm Motors to Byron Jackson Pumps. Sinclair Texas Pipe Line Co., Troupe, Tex.

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To eliminate coupling difficulties on pumps, on drill rigs, or in the refinery—specify *genuine* Fast's Couplings.

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FAST'S SELF-ALIGNING COUPLINGS

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plumb, the case is clamped against movement about the horizontal axis. Following this, the case is turned about the vertical axis until the needle coincides with the index within the case. The case is then clamped against further movement about the vertical axis. The observation having thus been completed, the instrument is removed from the eyes for reading the vertical angle and the magnetic azimuth of the line of sight, thus completing the entire determination.

It will be noted that the offset construction of the sight tube permits observation of any vertical angle from zenith to nadir. In some high vertical-angle observations for magnetic azimuth, the observer's face restricts rotation of the case about the vertical axis. Such observations may be made with the telescope inverted, when 180° added to or subtracted from the indicated horizontal angle will give the actual magnetic azimuth. The vertical angle requires no correction.

After a half-hour's practice, those who have tried the instrument have found that magnetic bearing of a course can be repeatedly taken and read within a fraction of a degree. The time required for a combined observation (vertical angle and magnetic azimuth) is less than that of the conventional style compass with which one obtains only a comparatively rough reading of azimuth alone.

Dip-and-strike determinations may be made in several ways: (1) A single dip "shot" gives the dip and the azimuth of the dip (90° from the strike). (2) The instrument may be held at eye-level and the sight tube rotated in a plane at right angles to the strike of the beds until the axis of the sight tube is parallel to the bedding. This gives the dip. The strike of the beds must then be determined by a separate observation. (3) The case of the instrument may be applied directly to a bedding plane for the purpose of determining dip and the direction of strike. The latter's magnetic azimuth must then be determined in a separate observation. (4) The dip and strike of a hanging wall of rock can be determined by applying the sight tube to the rock surface and observing level and needle from beneath the case, through the transparent inside level.

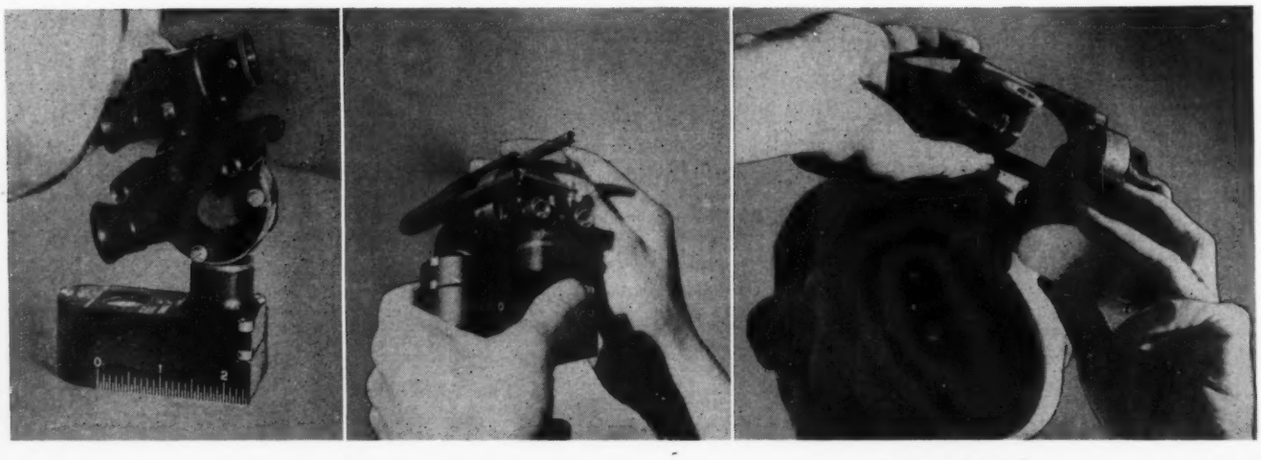
Top—The instrument mounted on a tripod for use as a transit. Bottom—Closeup showing a reading of horizontal angle

When used as a transit or as a plane-table alidade, the sight tube is removed from the head of the instrument and is replaced in an inverted position on the opposite side of the head to that which it ordinarily occupies. In this way, the line of collimation may be made to intersect the vertical axis of the instrument. A screw-hole in the bottom of the case is provided for attachment to a light tripod, either with or without a ball-and-socket leveling top. In reconnaissance work there are many occasions when the instrument may be advantageously leveled on a rock, fence-post, or other firm support. When properly leveled on any firm support, horizontal and vertical angles may be turned-off with this instrument as with any other transit.

This reversal of the sight tube in the head makes the instrument balance and stand firm on the plane table without additional support. In this service, the vertical-axis clamp screw is kept tightened after having turned the horizontal axis so that it is perpendicular to one of the sides of the case. This is easily accomplished by means of the horizontal-angle indicator when the magnetic declination set-off on the instrument is known. The squared end of the case may be used with a straight-edge so that the instrument forms its own parallel rule. One of the straight edges of the case is divided into inches and twentieths. The telescope is provided with stadia- as well as cross-hairs. The combination of these features makes the instrument a self-contained alidade with which most reconnaissance plane-table surveying may be easily and quickly executed.

The fields of usefulness of the instrument include petroleum, civil, and mining engineering, various military uses, forestry, and scientific work such as geophysics and geology.

Left—Using the instrument as a plane table alidade. Center—Using the instrument as a clinometer. Right—Making an observation for magnetic azimuth



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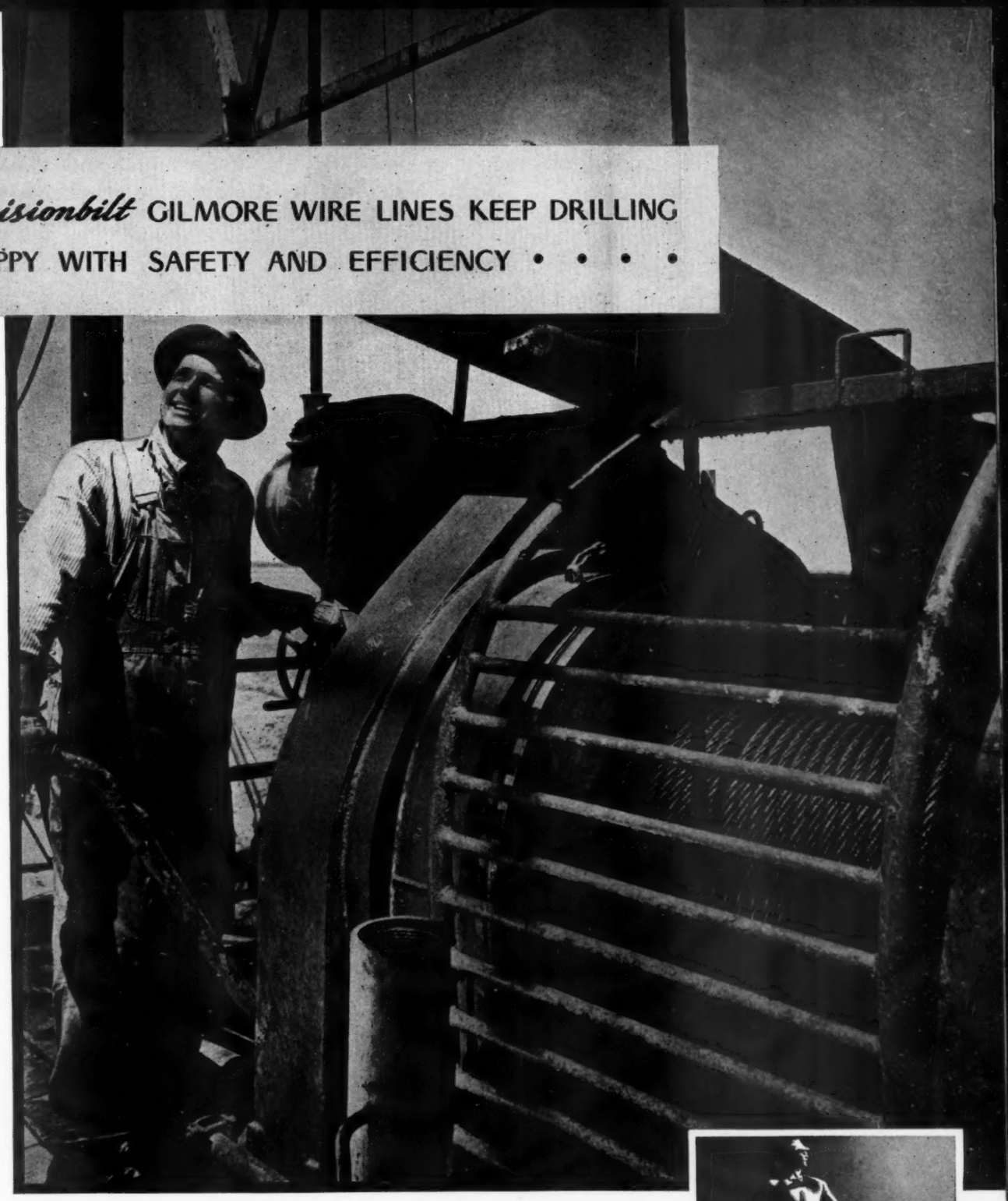

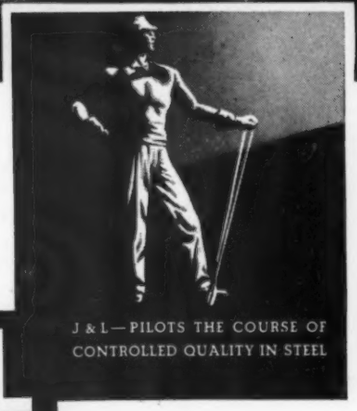

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A hand-operated cleaning device that rotates and is moved along the pipe

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
C. M. TAYLOR
Vice-President, The Lincoln Electric Company

The Use of Arc-Welding in Reconditioning Pipe Lines

Fill-in of pits when corroded area is small; half-soles of good pipe welded over large pitted areas, are accepted methods of repairing pipe

THE life of pipe buried in the ground depends principally upon how well the pipe is protected, if at all, by paint and wrapping and upon the corrosive properties of the soil contacting the pipe.

Under ordinary soil conditions, properly protected steel pipe usually lasts 20 to 30 years before replacement or reconditioning is necessary. Because the corrosive properties of soils vary so widely, however, even along the same pipe line, many maintenance departments find it advisable to conduct a systematic program of leakage tests, inspection, and repair at all times, regardless of the length of service of the line.

Various methods are used today to repair corroded pipe.

Repair of Oil Pipe Lines Under Pressure

Ordinarily, oil lines can be reconditioned by means of arc-welding without interrupting the service of the line. The line is kept operating under normal pressure, avoiding shutdown losses and, moreover, precluding the possibility of gas pockets that might be encountered in an empty or partly-filled line.

The first operation involves uncovering the line, a section at a time. A trencher is generally used, supplemented by spading, to remove the dirt. Sections ranging in length from a few hundred feet to one or two miles are uncovered, the amount depending upon the length of the line to be reconditioned, the terrain, etc.

All dirt, rust, and scale are then removed from the pipe. One type of cleaner is a hand-operated device that rotates and is moved along the pipe, scraping off all foreign material. When long sections of line are uncovered, a gas-engine-driven cleaning machine that rides the pipe is generally employed. Often two cleaning machines are used, one following the other, to assure the complete removal of all rust and scale. To further clean the pipe, it is often washed by gasoline after the scale and rust have been removed.

Careful inspection, aided by a pointed hammer, reveals the pits and corroded areas. The inspector employs

C. M. TAYLOR

graduated from Western Reserve University in June, 1916—Went to work for The Lincoln Electric Company immediately following graduation and remained until the summer of 1917, when he entered the Air Corps Service — Returned from government service in January, 1919—His first position was as clerk in the production department, then time study department, assistant superintendent, superintendent, and in 1928 vice-president in charge of sales—Serves on the board of directors of The Lincoln Electric Company.

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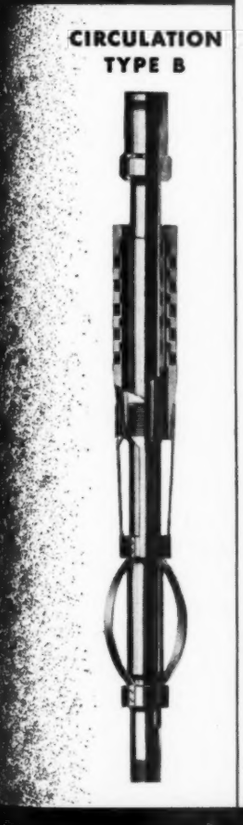

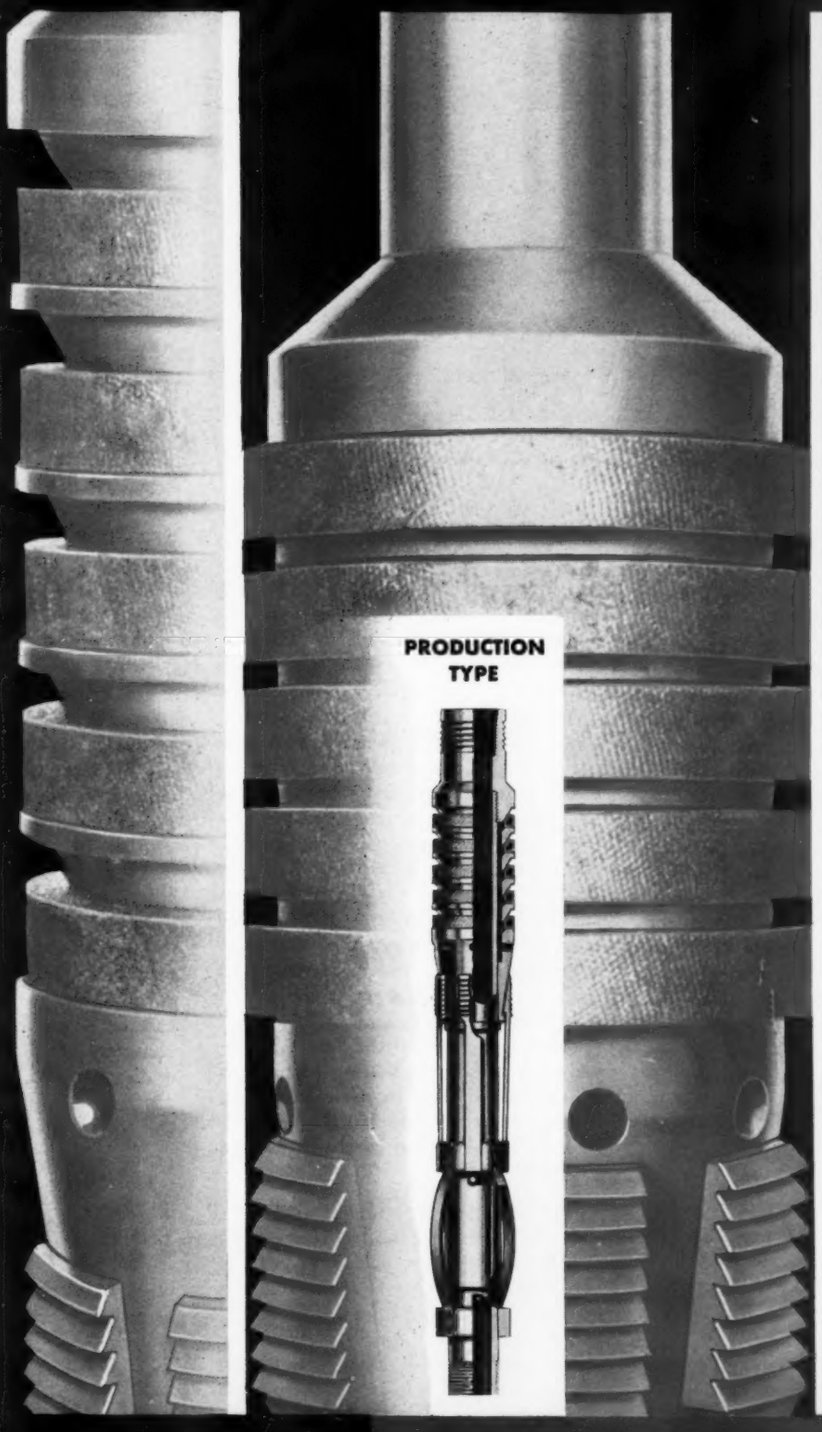

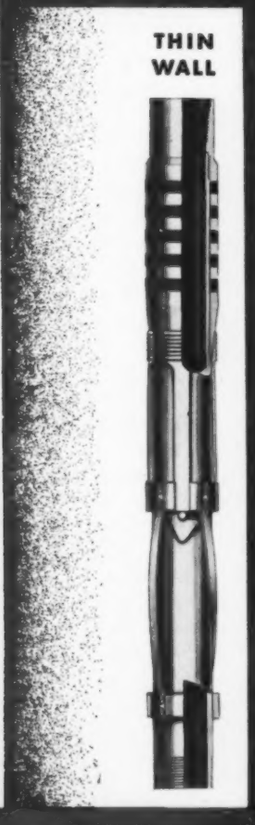

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Small pitted areas are filled with weld metal. These workmen are removing scale from the pipe to disclose corroded spots. Note half-sole on bottom of pipe

a pit gauge to determine the depth of the corroded areas. If the pit is deeper than 10 to 15 percent of the wall thickness, it is repaired. Pit holes are chalked by the inspector.

If the chalked pit holes are not too numerous, they are filled by weld metal. In welding pits, care should be taken to avoid burning through the pipe or maintaining the arc too long in one spot. Pits filled-in by this method may vary in size to areas of almost a square foot. Often more than one layer of weld metal is required to build-up the corroded spot flush with the pipe. Electrodes, either 1/4 in. or 3/16 in. (the latter for overhead welds), are generally used. When corrosion is more extensive, it is usually advisable to weld-on sections of new steel, either half way or all the way around the worn pipe. The following procedure is used by one large company.

Half-soles are cut in desired lengths from new pipe of the same diameter as the pipe being repaired, or are rolled to proper shape from new steel plates about 3/8-in. thick. These are then clamped and tack-welded in place. After tack-welding, the clamp is removed and the half-sole is lap-welded along both longitudinal and girth seams, providing a jacket that is permanently tight.

If there are leaks in the old pipe through which oil is escaping, a gasket may be placed over the hole after which the half-sole plate is fitted over the gasket to shut-off the oil until welding is completed.

Two beads are recommended for these welds. The first bead is run with 5/32-in. electrode, the second with 3/16-in. or 1/4-in. electrode. A combination of these two beads results in a permanently leakproof joint. The girth welds, (vertical and overhead), are usually made with 3/16-in. V electrode.

If pipe at collars, or couplings, is not in very bad condition, showing only minor leakage, both sides of the collar can be lap-welded to the pipe. These girth welds are usually made with 3/16-in. V electrode.

When leakage at collars is serious, the collar is usually jacketed with steel half-soles, cut from new pipe. This requires two half-soles cut from the same size pipe as the line itself, plus a section about 2 in. wide due to the extra diameter of the collar. The half-sole jacket can also be cut from the next larger size pipe. The ends of the collar jacket can then be heated with a cutting torch and hammered down to fit against the pipe adjacent to the collar. Girth lap-welds are then made.

After welding on the line is completed, a protective coating of paint is usually added and, in some instances, the line is wrapped for further protection. It is then relaid in the ditch and covered.

Oil Lines Repaired Out of Service

Under extreme conditions when the effects of corrosion make a complete overhaul necessary and require replacement of considerable pipe, the work, of course, will be done with the line out of operation. The work is much the same as for repairs made when the line is in operation except for replacing new sections of pipe that are welded into the old line. When a considerable stretch of line is to be replaced, the new pipe is placed on dollies and welded into sections about 80 ft. long, and then welded into the existing line.

Corrosion of the pipe is usually three to four times as bad on the bottom of the pipe as on the top half. Because of this, most companies turn the pipe over at the time of reconditioning so that the former top will be the bottom of the line when it is relaid. This is done when the old screwed couplings are to be welded to the pipe and especially in cases when the condition of the pipe is bad and when there are not too many bends.

Repair of Gas Pipe Lines Under Pressure

Many natural gas pipe lines are repaired in service under full pressure by a procedure similar to that described in the repair of oil lines. Welding under pressure is considered safer than welding a line that is full of gas without pressure, because under this latter condition, explosive mixtures of gas and air might be encountered.

When small leaks are encountered, a quick bead can be run over the leak to stop it, then a permanent weld made. If the leak is bad, it is patched by welding a jacket to the pipe. As a precaution, it is advisable to have a shovelful of loose dirt and a gas-fire extinguisher nearby when welding under leaky conditions.

Repairing Gas Lines Out of Service

Many companies find it necessary in repairing gas lines to recondition the couplings as well as the pipe. In this case or when the line is to be given a complete overhaul, service on the line is discontinued. There are two general practices used in reconditioning lines in this manner.

Some companies do their reconditioning work at a central plant, others do it along the pipe-line right-of-way. The procedure used in each case is virtually identical. When the central plant method is used, the worn sections of pipe are usually replaced by new or reclaimed pipe as soon as they are removed, thus requiring a stock of replacement pipe.

Following is the procedure used by one large gas company in a complete reconditioning job in which all work was done along the right-of-way. The particular case is that of a 16-in. line, 25 miles long, originally laid in 20-ft.

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Once again, Harrisburg Steel Corporation takes occasion to wish its many friends in Industry a very Merry Christmas and a prosperous New Year ...We are sincerely appreciative of the opportunities given us to serve Industry with steel and steel products. And in the coming year you'll find us – with the experience of eighty-six years and an untiring enthusiasm as fresh as tomorrow – "yours to command."

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An old threaded coupling covered by new steel plate. On the right, new steel plate has been added all around the pipe. On the left, the half-sole has been applied only on the bottom of the pipe

lengths joined by couplings. The line was laid about 25 years ago.

The exact location of the pipe was determined by means of rods forced into the ground. The route was marked by stakes and a trencher was used to remove the earth from above the pipe. The pipe was then lifted clear of the ditch and supported by means of timbers that straddled the ditch. The coupling bolts were cut with a cutting torch and the pipe sections placed on one side of the ditch. Dirt, scale, and rust were removed from the pipe by a crew of four men. Most of the cleaning was done by pounding with hammers. Corroded areas were dug out by an inspector who used a pointed hammer and chisel and encircled the bad spots with chalk marks.

As a part of the work, this particular line was welded into 80-ft. sections and then coupled. The joining of the 20-ft. sections was by the usual firing-line method of pipe welding. In other words, the sections were mounted on dollies, back-up rings were inserted into the ends, and the pipe was then lined-up and tack-welded to the adjacent section. The finished roll weld was then made with two passes.

The 80-ft. sections of pipe were placed on dollies so that the pipe could be turned to expose the corroded areas to be welded. The size of the corroded areas varied from spots about 1 in. in diameter to large areas 1 ft. long and nearly 1 ft. wide. (In the case of large areas, some companies use patches rather than fill in with weld metal.)

The welding procedure consisted of laying weld metal with $\frac{3}{8}$-in. electrodes, welding in the down hand position. Use of electrodes of this size, at currents of 300 to 350 amp., speeds-up the job. In some cases, when corrosion is excessive, the entire 20-ft. section of pipe may be replaced by new pipe. In the case of this particular line, approximately $1\frac{1}{4}$ miles of replacement pipe were required for the 25 miles of line.

As each 80-ft. section of the pipe was completed, it was tested to a pressure 25 percent greater than the maximum service pressure to which the line will be subjected. The stress test was followed by a pressure-drop test to insure freedom from leakage.

In those sections of the line where corrosive conditions were most severe, the pipe was given a protective coating of rustproof compound such as bituminous paint.

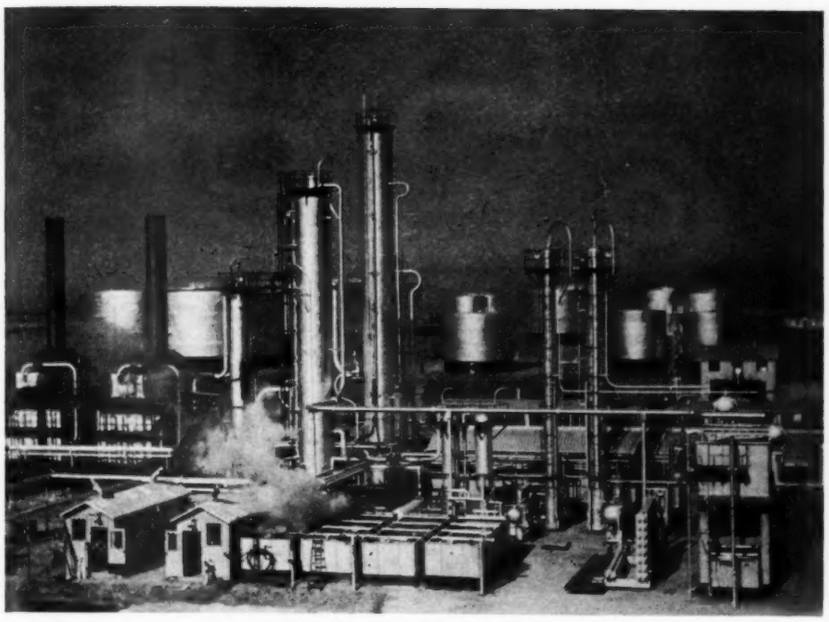
The 80-ft. sections of pipe were then joined by the old couplings, using new rubbers and new bolts, and the pipe lowered into the ditch and covered.

Repair of Gasoline Pipe Lines

On a 10-in. gasoline line reconditioned in the Mid-Continent area, the pipe was repair-welded under 600-lb. pressure. Badly corroded areas were half-soled as outlined previously. When corrosion was spotty, the pits were filled by weld metal. In order to minimize heating of the gasoline where pits were deep, they were covered with one or more lengths of bare rod, tack-welded across the pit and then welded-over.

The procedure followed in this work was to remove the scale thoroughly and expose sound metal; then determine the amount of metal required to fill the area. When the corrosion is not severe one or two filler rods may suffice. When the area is quite large, several rods may be required. In either case, the rods are tacked in place, then welded over, making a reinforcing weld. This method is effective when pits are deep and eliminates the possibility of burning-through.

Deep pit that has been covered by filler rods welded to the pipe



General view of Glacier Production Company's 4400-bbl. refinery at Cut Bank, Montana

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

Montana Refinery Provides Processing Facilities for Cut Bank Crude Oil

New 4400-bbl. plant will process oil for several producing companies and relieve a situation made acute by a loss of Canadian markets since development of Turner Valley field

COMPLETION of Glacier Production Company's new refinery at Cut Bank, Montana, is a development of major importance in Montana's growing petroleum industry. This project at Cut Bank is attracting widespread interest by reason of its performance. Constructed by Bechtel-McCone-Parsons Corporation of Los Angeles, the refinery was designed to have a charge capacity of 4400 bbl. per day when producing gasoline, tractor fuel, and locomotive fuel oil. Data from test runs show 75 percent recovery of finished gasoline having an octane number of 75 and an end point of 385° F., and 20 percent fuel oil (150 SSF at 122° F.), with gas and loss restricted to 5 percent. Cut Bank crude oil, obtained from sands at a depth of 2900 ft., is a 37-39° A.P.I. gravity oil substantially free of solids and water.

Processing is accomplished in a continuous operation from crude storage to finished storage without intermediate rundown, eliminating extra handling and possible causes of deterioration. Unusual combinations of modern process equipment have been employed, not only to produce a highly satisfactory yield, but also to provide flexibility enabling the refiner to meet a variety of product specifications. This requirement was established because the Glacier Production Company refines for several marketers.

Market Situation Responsible for Construction

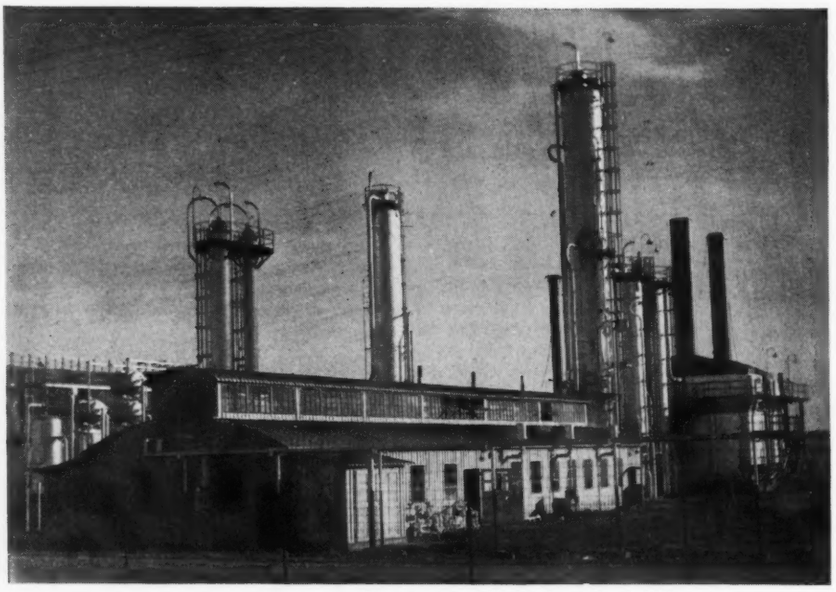
Glacier Production Company is essentially a public utility, supplying fuel gas distributed through its own lines to Helena, Butte, and other Montana communities. It is wholly owned by the Montana Power Company. While engaged in developing natural gas reserves in the Cut Bank field during 1932, Glacier's activities led to the discovery of oil, an eventuality that caused the company to enter the petroleum business as a producer. At present the Cut Bank field yields 56 percent of Montana's entire production, and Glacier wells produce one-third of the Cut Bank total. Independent producers are also active; prior to 1937 their output (and Glacier's) was sold to Canadian refiners. In that year, however, development of production in the Turner Valley field in Alberta had increased until this field's crude oil volume was sufficient to meet Canadian refining requirements, and northern Montana producers lost their export outlet.

Faced by a serious economic problem, Glacier found a solution by studying the marketing situation then existing in Montana. Although a portion of the crude oil produced in the state had been sold in export, one-third of Montana's gasoline requirements were being obtained from refineries in Wyoming, California, and the Mid-Continent. This potential local market for finished products from Cut Bank crude oil was the principal factor in Glacier's decision to build the newly-completed modern refinery.

Agreement to Refine for Socony-Vacuum

Following the loss of the Canadian market, a group of independent producers at Cut Bank pooled their interests and made arrangements to sell their output to the Socony-Vacuum Oil Company. The latter company had been considering the erection of a similar refinery, but with construction under way on Glacier's plant, it was decided that a duplicate investment should be avoided. An agreement was executed whereby Glacier refines to Socony-Vacuum's specifications and holds this company's finished products in separate storage for delivery as required.

This consolidation of activities proved beneficial to all parties concerned, for it brought about economic stabilization of the crude oil situation at Cut Bank. From Glacier's standpoint, expansion of capacity allowed



The control room, hot-pump room, and cold-pump room are housed in this insulated steel building

installation of the most modern processes and facilities, and permitted a layout of sufficient size to provide low operating costs.

Constructed in two stages, the original plant, planned to handle only Glacier's own crude, was designed to process 1650 bbl. per day. Construction on the initial units began in March, 1939, and this part of the plant has been in operation since June 29, processing a volume consistently in excess of the daily 1650 bbl. planned. Completion of additional facilities now results in a 4400-bbl. refinery, producing straight-run gasoline, composite gasoline, tractor fuel, and locomotive fuel oil. The initial plant was shutdown for tying-in added equipment, and operation was resumed at full capacity September 20.

The Refinery

The Glacier Production Company's refinery at Cut Bank consists of a crude oil distillation unit, a 2-coil selective Dubbs cracking unit, a catalytic polymerization plant by Universal Oil Products Company, a Perco sweetening unit and ethylizing equipment as the basic processes, together with all necessary auxiliary apparatus, and adequate storage and loading facilities.

Process design supplied by Universal Oil Products Company was followed in the construction of the Dubbs cracking unit and the polymerization plant, which processes are licensed to Glacier by Universal Oil Products. The Perco treating plant was constructed in accordance with process design, specifications, and drawings provided by the licensor of this process, Perco Incorporated. The ethyl-blending plant, licensed by the Ethyl Gasoline Corporation, was built to that company's specifications.

Prior to construction of the new refinery, Glacier had in operation at Cut Bank a modern absorption plant producing natural gasoline. Office, dwelling, and shop facilities maintained at this plant, as well as steam, gas, water, and other utilities were available for use by the refinery, thereby effecting economies in installation and operating costs.

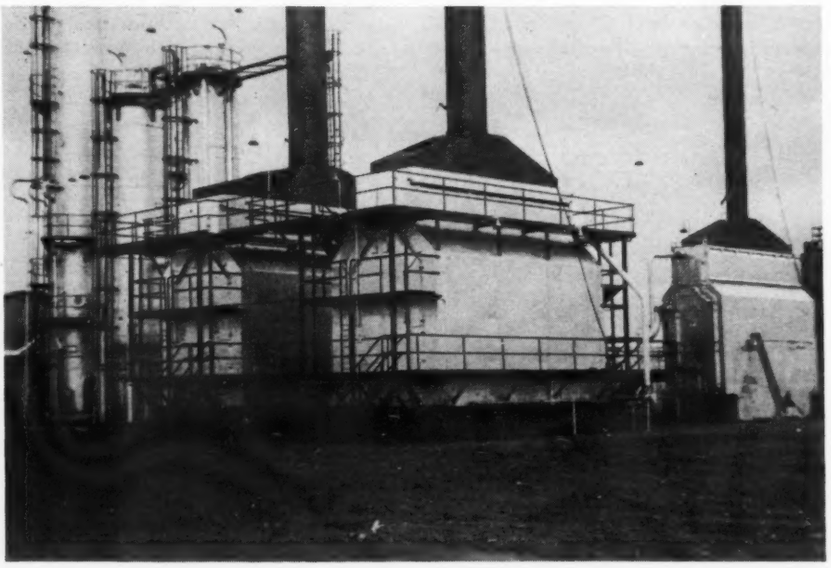
Plant Performance Features

Desired performance features of the Glacier plant were established at the outset. The refinery was built to meet specific requirements growing out of the processor's individual situation, as dictated by his marketing arrangements.

The first essential was to erect a plant capable of producing a maximum yield of high octane gasoline, together with other readily salable products. Operating data show this requirement has been fulfilled in a highly satisfactory manner. Second, the refiner sought efficient and economic operation—an end attained by a variety of means, not the least of which is the flow arrangement permitting coördination of all operations necessary to produce finished gasoline in a single, uninterrupted run from crude storage through manufacture and then to finished storage.

Glacier serves several marketer-customers. It was necessary, therefore, to provide flexibility and close control. Products are made to meet various product specifications. This is accomplished by the inclusion of a number of process units arranged to deliver a variety of product streams separately or concurrently. A large number of instruments and controls has been installed, and flow through the plant is readily adjustable for the various products. Treating equipment accommodates one stream or several streams as produced.

In planning, provision for expansion was made at the outset. Thus, when the Socony-Vacuum contract was executed, Bechtel-McCone-Parsons Corporation engineers were able to add the necessary facilities with a mini-



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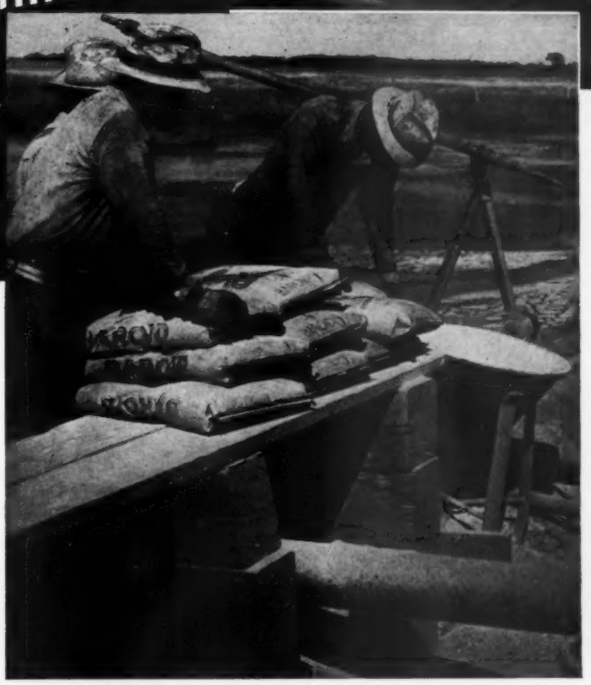

We congratulate Continental Oil Company and Fain Drilling Company on their achievement.

Once again, proper selection and careful control of drilling mud have proved their value in minimizing drilling difficulties.

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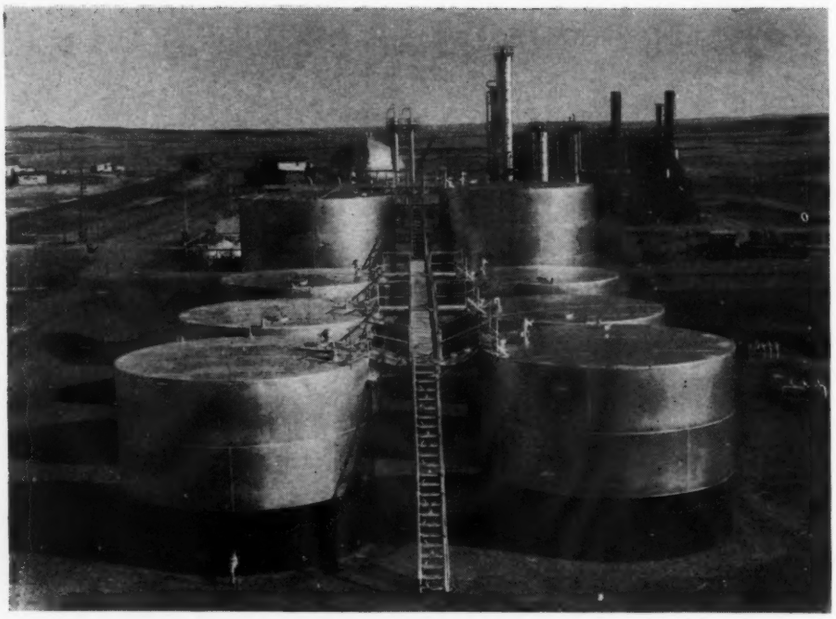


A few of the storage tanks. Storage capacity for crude oil and finished products is 500,000 bbl.

mum of changes. The present arrangement is such that at any time, additional expansion can be made to provide increased capacity, or for the inclusion of future developments in the refining processes. When required by demand, a larger volume of polymer gasoline can be produced through the installation of butane-cracking facilities. The present polymerization plant with its stabilization equipment is of sufficient capacity to meet this later requirement.

Quality was a prime essential. Processes and equipment were to be the most modern and efficient available. In its operation the refinery employs the latest developments in distillation, cracking, polymerization, and treating. An inspection of equipment and workmanship reveals the excellence and permanence of both.

The contractor's engineers and representatives of the process licensors had the benefit of close coöperation on the part of E. M. Parkin, Glacier Production Company's refinery superintendent, enabling them to incorporate fully all the operating features desired by the refiner.

Instruments and Controls

Observation and regulation of temperatures and pressures throughout the process equipment are provided by centrally-placed instruments and controls on a panel in the main pump and control house. Detailed operations of the entire plant can be watched closely at all times.

Recording temperature and flow controllers have been provided at all essential points. Recording potentiometers give continuous records of furnace outlet temperatures and indicating potentiometric points are provided for checking temperatures at important points throughout the refinery. Parsons double-duty, remote-control dropout valves have been installed so the entire plant may be shutdown from the control room. When manual control is desired, valve wheels extend into the control room from a number of oil and gas streams. Remote manual control by means of extension shafts permits close regulation of the reaction chamber drawoff valve and the light-oil furnace back-pressure valve, by means of highly-backgeared handwheels on the control panel.

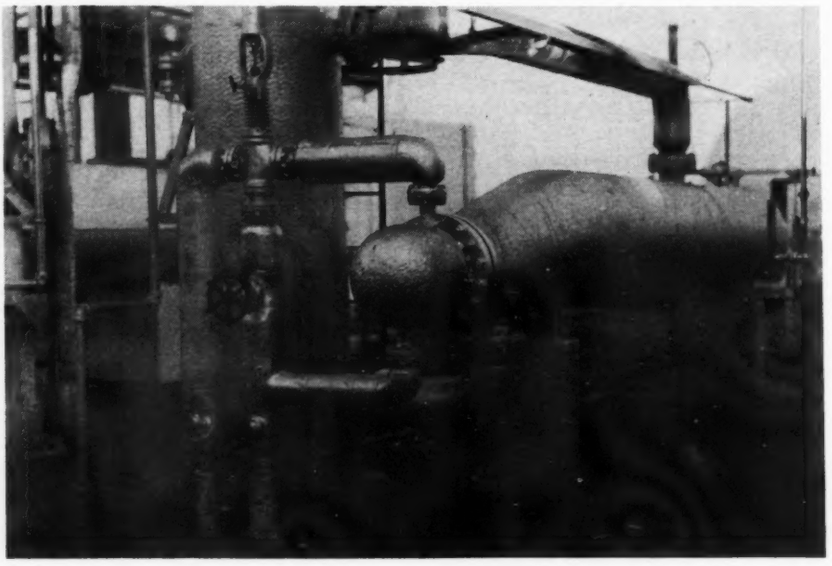
Seasonal Demand Met by Storage Arrangement

Montana refiners experience a fluctuation of demand for finished products probably varying to a greater degree than that occurring elsewhere. Proper correlation of this highly seasonal market with the refinery's steady production rate was made the subject of extensive study. The tankage plan adopted permits proportioned storage capacity for the various finished products, allowing accumulation of stocks during the quiet winter months so that they will be available to satisfy the brisk demand in spring and summer. Adequate rundown tanks permit careful checking of products enroute to storage. Tankage for crude and finished products is in excess of 500,000 bbl.

Refinery Operation

When the plant was placed in operation the contractor's engineers and representatives of the process licensors coöperated to train Glacier's operating crews. Operators of the Universal Oil Products Company's organization directed the initial runs of the cracking unit and the catalytic polymerization plant. Initial operation of the treating plant was directed by qualified men provided by Perco Incorporated and the ethylizing equipment was placed in operation by a representative of the Ethyl Gasoline Corporation.

The Bechtel-McCone-Parsons Corporation organization coördinated operation of the processes and auxiliary apparatus involved, and supervised the initial runs of the refinery as a whole.



Polymerization plant reboiler

FRICK-REID
FRICK-REID

P 069.
P 615.511

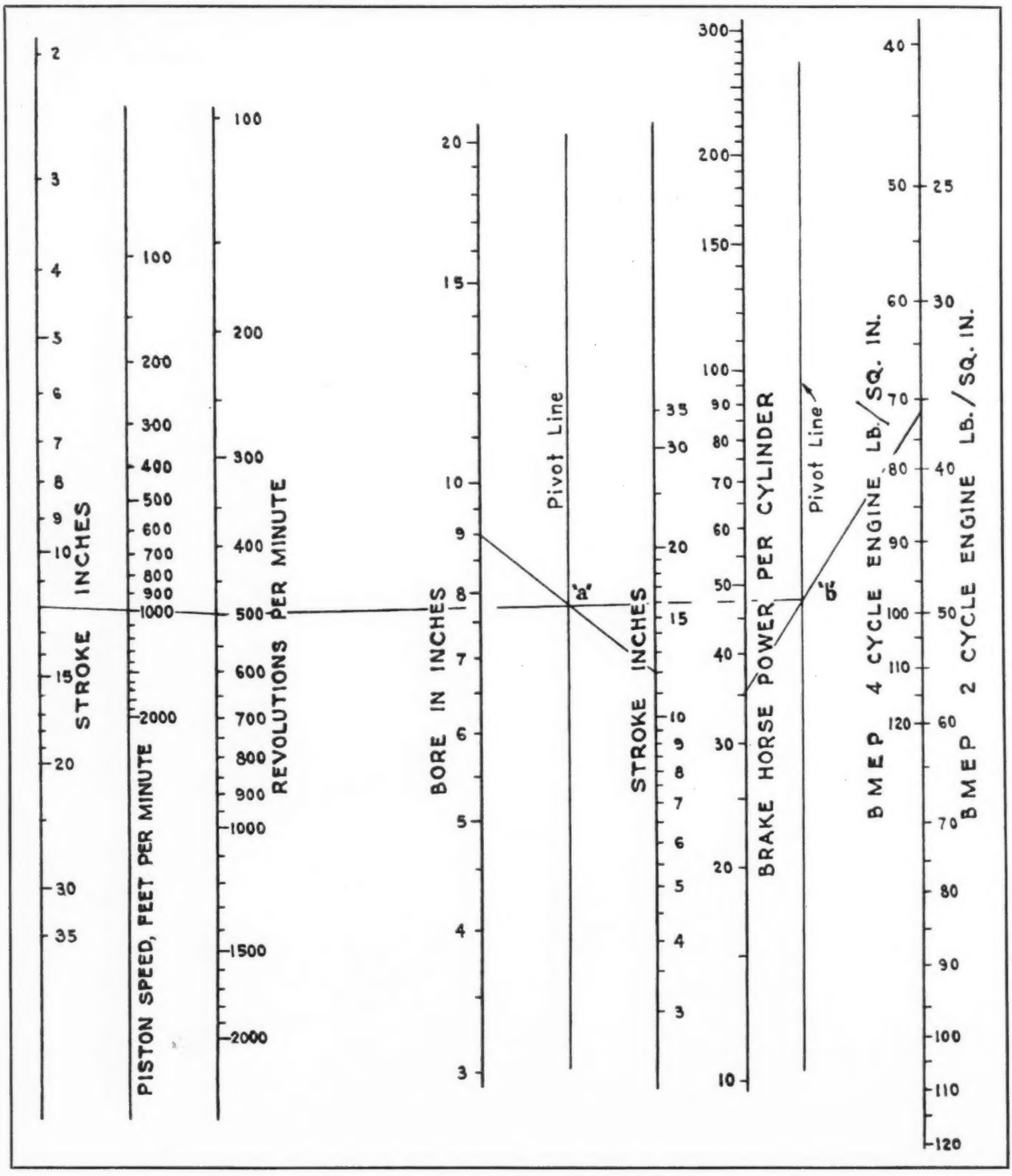
Alignment Chart for Estimating the Mean Effective Pressure and Piston Speed of an Engine

By FRANK E. HANGS

EXAMPLE

Given: 9 by 12 engine at 500 r.p.m., 35 b.hp. per cylinder, 4 cycle.

1. Connect bore and stroke to determine "a".
2. Draw line through 500 r.p.m. and "a" to determine "b".
3. Read 72 lb./sq. in. b.m.e.p. on line through 35 b.hp. and "b".
4. Connect 500 r.p.m. with 12-in. stroke (left scale). Read 1000 ft. per min.



This Industry of Ours

AN INSIDE LOOK AT THE OIL INDUSTRY AND THE LOT OF THOSE WHO SERVE IT

By NORTH BIGBEE

Part 4 — Concluded

Revealing facts concerning wages, working hours, and working and living conditions of petroleum's vast family of employees

THE production head of one of the larger Mid-Continent oil companies was showing a party of officers of its eastern affiliate around the company's newest oil field.

In keeping with the importance of the occasion, the company official had dressed in his best, with a new fall suit and overcoat to protect him from the chilling gusts of the first norther of the year.

Up in the derrick it was, if anything, even colder. The derrickman had been fighting it out with the norther all morning on the thribble board. With each stand he racked, his hands got a little number and his nose a little colder. Warmly dressed as he was, he was shivering despite his exertions as he pushed and tugged the last stand of drill pipe into place.

Down below, the company official and his eastern friends looked pretty far away standing by the slushpit talking to the toolpusher and some of the roughnecks. But it was the boilers that held the derrickman's eyes. There was so much heat going to waste down there, and the driller wasn't going to need him for a few minutes anyway. Why not go down and get warm?

So picking his way carefully across the wet platform he unbuckled his safety belt and stepped around and onto the ladder.

He hadn't descended more than four or five rungs when the hand he was taking hold with slid suddenly across the slickened rung and then slipped off its side. Grabbing desperately with his other hand, he clawed the air as his overbalanced body fell backward and down.

The company official and the other men below heard the agonized scream as he fell. Twisting crazily, his body landed heavily in the slushpit.

There were several others closer to the slushpit than the company official. But it was he who acted. Plunging into the muddy mass of the pit, he fumbled for the body of the unconscious derrickman and lifted the gray hulk up on his shoulders. Then he carried him to the boiler porch and helped revive him.

By the time the man was able to talk again, the official had wiped off most of the slush he'd acquired in the rescue. When the derrickman began thanking him, the shivering production head dismissed his gratitude with a grayish grin.

"Hell," he said, "you'd have done the same for me!"

Not long before this, the president of the same company had defined its policy in a statement that included the sentence, "Intimate and friendly relations exist between the management and the employees." This incident is only one of the more striking illustrations that the company practiced what it preached; and this is true throughout the oil industry.

This is the concluding article of the series, the purpose of which was to present to our readers an inside look at the oil industry and the lot of those who serve it. Of all the facts the study has disclosed perhaps the most striking are the prevailing high standard of working and living conditions and the liberal wage scales of oil employees compared with those of other industries. This excellent record—in which the industry and its workers may well take pride—probably accounts for the cordial relations existing between employer and employee in the petroleum industry.

Preparation of this series has involved months of research on personnel relations in the industry. Many company officials and field men were interviewed in the course of this work, and it was gratifying to find a ready willingness to co-operate in supplying factual information, in frankly discussing company relations, and in giving freely of their time to the author. —*The Editor.*

Democracy of Oil

In few industries but oil would a new vice-president and general manager of a big corporation appeal frankly to his personnel director for aid in trying to orient himself to his latest position, as did an oil company executive recently.

"I started to work as a bookkeeper for this company," he told the personnel head. "I've worked for it all my life, and now that I'm an executive, I still feel and think and make my decisions as I did when I was just another employee."

As the personnel man soon assured him, this feeling is not at all unusual for a petroleum executive. In fact, so many have come up year by year and job by job to positions of responsibility that they still see a problem from the employee's angle first, and make their minds up on that basis.

Or take the case of the organizing head of several of the largest companies in the oil industry.

Paying an unprecedented visit to one of his corporation's operating headquarters, he wandered off after an hour or two with the company heads, who spent the rest of the day trying to find him. When they did find him, it was in the company's research department, temporarily housed in the oldest building at the refinery plant. Here the financier had spent a very enjoyable day with a group of young engineers, listening to them describe their research problems and their attempts to solve them.

Incidents like these, true and carrying the salty tang of the industry, tell more about the informal and friendly relations existing in the oil business than many pages of discussion. Yet such anecdotes are common. Any oilman can offer two or three favorites of his own to match or top these.

But they constitute considerably more than merely amusing stories. They are the down-to-earth examples of the pervasive code of democracy under which the oil industry was born and under which it still operates. That's a code of a kind that governments do not create and courts cannot destroy. It is the one that has guided the oil business from its shoestring beginnings to its present eminence.

Indeed, so successful has been oil's operation under this industrial philosophy that from "Colonel" Drake's tin-cup triumph of 1859 through 1930, the output of petroleum has far outstripped the production expansion of virtually all other minerals. Between 1881 and 1930, for example, the output of oil increased three times as rapidly as that of copper, lead, phosphate rock, or pig iron and about twice as fast as zinc or stone. During the post-war decade, moreover, when the rate of growth for many important minerals was retarded, crude petroleum output made its biggest gains.

Even the depression slowed down for only two years the steady expansion of this relatively young industry. Resuming its upward trend in 1932, petroleum has since continued to establish new records only to topple them the next year. Of a total production to date of approximately 22,300,000,000 bbl., the industry has produced approximately 96 percent since the birth of the current century and more than three-fourths since the last futile fusillade of the first World War.

Such figures, impressive as they may be in themselves, nevertheless have a more important meaning for the student of industry. Essentially they are a tribute to the men who establish these records of progress by their work and planning, and to the industry whose opportunities were such as to attract men of so great capabilities. Fundamentally, then, the oil business' remarkable attainments in four-score years are the result of a successful policy of industrial relations keeping pace with a naturally expanding demand, and offering rewards that far exceeded the industry's early hardships. You may be sure Titusville, Pithole, and Babylon had their stories of sudden wealth in oil just as fabulous in their way and in their day as subsequent ones at Spindletop, Seminole, and East Texas.

Two-Tour Days

Not that there weren't plenty of hardships. At the beginning of the industry, the hours each employee worked varied somewhat, but the working day was prevailingly long. In some cases, men were kept at their tasks 18 to 20 hours a day.

Doubtless they had the same trouble as the darkey janitor in the later boomtown of Ranger. Each day he swept out two stores, all the offices in a three-story building, cleaned up two theaters, the Western Union office, a dance hall, and a bath-house. He never worked less than 20 hours a day.

"Don't you ever stop?" an oilman asked him one day as he was hurrying on to his next job.

"Nassuh," was his grinning answer. "If I evah stops, I goes to sleep right now."

It was around 1890 when the oil industry first established regular and definite hours. Refinery employees in general were put on an 84-hour week of 12 hours a day for seven days a week. Later this working schedule was reduced to a six-day week, although the 12-hour day was retained.

It was in 1914 that employees in the 24-hour continuous shift operations such as drilling, oil-lifting, pipe-line pumping, and refining first got away from the 12-hour shifts and (for most of them) seven-day weeks. By the close of the World War, the industry in general had cut its work week for these employees from 84 to 56 hours, or seven eight-hour shifts.

This progressive move not only greatly increased the rest and leisure time of the men already employed but also resulted in the hiring of one-third more workers. By this change, three instead of two men were required for each 24-hour job.

In field and pipe-line day maintenance work, some mechanics and laborers still worked seven 12-hour days for an 84-hour week in 1914. But many of them worked seven nine-hour days, or 63 hours. Those in refinery maintenance usually worked six nine-hour days or 54 hours a week.

Up through 1920, however, 74 percent of all field employees worked seven days a week and 19 percent of these workers were on a 12-hour shift each day. Thus 14.1 percent of all such workers were on the job 84 hours a week. Nearly half, or 45.2 percent, worked 60 or more hours whereas over three-fourths, or 77.2 percent, labored more than 56 hours weekly.

Even in 1928, nearly one-fourth, or 23.2 percent, were on the job for 12 hours a day, seven days a week. Those on a 60-hour week represented 51.9 percent whereas those employed 56 hours a week or less had increased from 22.8 percent in 1920 to 45.2 percent in 1928.

The trouble with most of the figures on wages and hours is the limited statistics in the earliest days of the oil business, which makes an overall picture difficult to construct. In fact, the sketchy collection of information on the industry was about as restricted and elementary as the sampling practiced at one of the pioneer coffeepot refineries of the East Texas field.

This plant consisted of an old steel oil drum, set up horizontally on some bricks with a fire under it, and a copper coil immersed in an aged beer keg filled with cold water. Sampling was accomplished by running a little of the product from a spigot on the end of the coil into an old tomato can. The "refiner" then set the can up at a few feet's distance and tossed lighted matches into it. If it burned, it was

gasoline. If it didn't, it was kerosene.

Prior to the National Industrial Recovery Act, hours were progressively reduced by petroleum until the normal schedules for most of the continuous shift operations were reduced to six eight-hour shifts or a 48-hour week. Under this plan a seventh man divided his time between each pair of 24-hour jobs. Yet in spite of the 43 percent reduction in hours worked per week (from 84 to 48) the employees still received more wages per week than in 1914.

In the maintenance divisions, similar schedules of hours were introduced, making the eight-hour day, six-day week standard there also. Weekly earnings of employees were increased here too.

Depression Crisis

During the depression years after 1929, the industry faced an unusual situation. With demand for products fairly well-sustained, prices for crude oil and refined products nevertheless declined to levels that reduced drastically or eliminated entirely profits on operations for many of the companies. Part of this may be attributed to the discovery of several large flush pools and the difficulties of regulating their production.

The discovery of the flush areas caused stagnation and consequent unemployment in many old pools, particularly those in or near the stripper class or too far from tidewater. Many stories are told of the trek from the older fields to East Texas. One was of two operators who, broke and trying to thumb their way from an old boomtown to the new field, were passed up by a large truck filled with cement blocks.

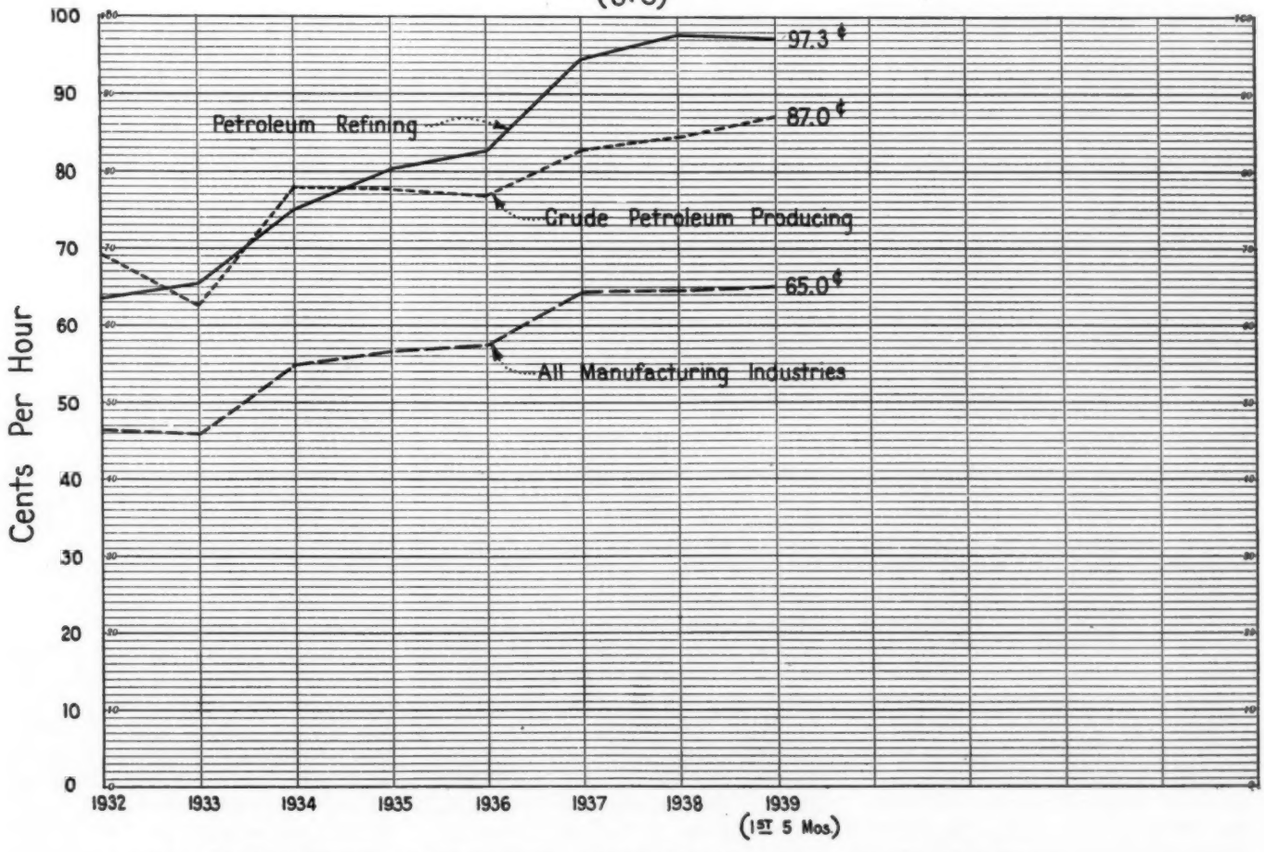
"That's the last straw," one of the oilmen moaned. "Even the sidewalks are moving to East Texas."

Due to the several causes, capital outlays for drilling in most fields and for plant extension were reduced and many of the companies introduced operating economies that they had deemed unimportant in the golden days. This reduced the total man-hours of labor in 1932 and early 1933.

Faced with a surplus of employees during this period, one of the leading oil companies in California, devised a plan whereby a certain number of employees (beginning with men of short service) would be placed on part time. This program soon spread to other companies and then was adopted generally by American industry as the share-the-work program.

The plan, although reducing the weekly wages of the individual employee, enabled a far greater number to receive income of some sort during even the hardest times. Employers, of course, had their same unit labor costs except in instances where the hourly wage rates were cut. Many of the oil companies and operators, however, made no cuts in hourly rates during the 1929-33 slump, and others cut not more than 10 percent. In fact, the average reduction in rates for the 20 largest companies was only 1.1 percent. This contrasted with other industries, some of which reduced rates 25 to 40 percent.

Furthermore, a number of the oil companies, to make employment, pushed-through projects that normally would not have been undertaken for



Data: United States Bureau of Labor Statistics Monthly Review

some time. For instance, one company laid a second pipe line from one of its fields to the coast at a cost of $500,000 a year and a half before it was scheduled. This gave employment throughout one winter for 300 to 500 men, operating on a four-day week basis to spread the work, who otherwise would have been without jobs. The oil industry as a whole showed a much smaller drop in employment during this period than most other mining industries.

Liberal Wage Increases

Then came the NIRA and the oil code. Under the code (promulgated in August and September, 1933) uniform maximum working hour limits were set at 36 hours average per week in production, pipe-line transportation, and refining. This was under a plan of not more than 72 hours work for any two weeks.

Not only did oil employers in general fall into line by putting the prescribed hours immediately into effect, but many, who had gone through the depression years to September, 1933, without cutting hourly wage rates, even increased these at once through voluntary action. Boosting these by an average of 29 percent, they restored total weekly earnings (as computed for May, 1934) to within 19 percent of 1929 levels. This was despite a 32 percent reduction in hours worked per week during the five-year period in production, pipe line, and refining.

With the collapse of the NIRA and with it the oil code, many of the employers voluntarily retained the shorter working schedules of the code. In fact, government figures for 1934 show that 32.2 percent of oil employees worked less than 36 hours a week, and 55.1 percent more worked from 36 to 44 hours a week. Only 12.7 percent labored 44 hours a week or longer.

The higher hourly wages also were retained, while the employees received the benefit of lowered living costs. Considering that the cost of living index in 1934 was only 80 percent of 1929, real wages were established in 1934 at 107 percent of 1929 levels.

From 1934 to 1939, further increases have been made by the petroleum industry in both hourly wage rates and actual weekly wages amounting to an additional 25 percent for each. These increases have considerably more than offset the simultaneous rise of 6 percent in the cost of living index.

The oil business' liberality in wage increases in the last 25 years and its generally advanced program of industrial relations indicate that the oil industry has always been progressive and advanced in its thinking beyond average American industry. An old-time roustabout and pumper, who rose step by step to become chairman of the board of one of the larger oil corporations, told the writer the other day, "I'll never forget my first raise. I was making $45 a month as a pumper and they finally raised me to $50. It seemed to me like all the money in the world."

As H. H. Anderson, who was chairman of the labor sub-committee of the Planning and Co-ordination Committee during oil code days, recently summed up oil's current labor record before the Temporary National Economic Committee:

"Compared to other reported industries, the average hourly rates in the production, refining, pipe line, and wholesale marketing branches are amongst the highest, the normally scheduled hours are low and their week-to-week regularity—as indicated by actual hours worked — is almost level.

"The average weekly earnings are virtually the greatest. No other large industry can show steadier employment at such high wages, more regular delivery of full pay envelopes, or more generous distribution of supplementary employee benefits. Few industries enjoy greater friendliness and coöperation between employers and employees.

"The petroleum industry is proud of its record as job-creator and of the high standards of employment and employee relations that it has developed without pressure from labor and without adverse cost increases to consumers."

And, as Mr. Anderson further reported, weekly earnings in the production pipe-line and refining divisions have been raised 60 percent since 1914 whereas hours worked per week have been reduced 43 percent. Hourly wage rates have been increased an average of 180 percent, and two and one-third men are now working where but one worked before.

Consumer Protected

All this has been done in the last 25 years. At the same time, the cost of gasoline, the principal petroleum product, to the consumer has been reduced by more than one-half. As for real earnings, petroleum was the only industry among comparable ones that paid its average worker more in 1938 than during the boom days of 1929.

"And," as Mr. Anderson adds, "the petroleum industry has not been satisfied with mere job-creation — it has consistently led in bringing shorter hours, higher earnings, and safer working conditions as well as greater opportunity and economic security to workers. Wage and hour and employment data published by various government bureaus or available from other sources give incontrovertible evidence of the outstanding fair treatment being received by employees in the petroleum industry."

That's a record in which the oil industry and every member of it can share with pride.

In fact, oil was so far ahead of industry in general that its refining and pipe-line divisions were already well below the maximum-hour provisions of the Fair Labor Standards Act adopted in 1938. Consequently, the act has had little effect in increasing employment in these branches of the industry and naturally only a moderate increase can be expected in the future.

As for production, although a number of larger employers in the producing division, as well as some drilling contractors, already were under the labor act maximum, others still worked their men 56 hours a week. To conform with the 44-hour maximum provisions, the latter firms have had to hire a considerable number of additional workers, and this has stimulated employment.

Further increases in the total of men employed in production are also due with the reduction in the second year to 42 hours, and again after two years when the work week will be limited to 40 hours.

As Corrington Gill, assistant commissioner of the Works Progress Administration, points out in his preface to the government study, *Petroleum and Natural Gas Production*, "The long-time trend shows a notable reduction in the length of the work day and the work week, and this reduction has been an important factor in maintaining and expanding employment in the industry."

Four-Day Week

Many workers in the industry have been enjoying this shortened work week now for a number of years. Some even have a four-day work week, twice a month, with two five-day work weeks. This is a worker's paradise compared with the earlier days of the industry when a man worked on a job until he finished it, even if it took 12 to 18 hours a day, seven days a week, for weeks or months on end.

The president of one of the larger companies was recalling the other day his beginnings in the oil business. Living six miles from where he worked and too poor to buy a horse, he got up at 4:30 each morning and walked the six miles to work, carrying his lunch, in order to get there by 7:00 o'clock. Then when his 12-hour day was over, he walked the six miles home again.

One of the most commendable things about the oil business has been that the industry itself took the lead in improving its own hours and wages without waiting on pressure either from government or labor. Furthermore, its progressive policies have had an important effect on improving standards for both wages and hours throughout all industry. With the hour maxima set by the Fair Labor Standards Act well above what much of the oil industry already enjoyed, industry in general is also far from catching up with petroleum in its higher wage standards as well.

But just how far ahead of other industries is petroleum in this vital phase of a successful operations policy? Every employee certainly has a right to know and a keen personal interest in knowing.

For, as a well-known petroleum industrial relations expert pointed out in a recent address, the oil worker expects four things of his company and his industry: (1) Knowledge of the circumstances affecting him in his work—an understanding of his industrial environment. (2) The feeling that he is growing—a sense of advancement. (3) The respect of his company and its executives for himself and his personality as an individual. (4) A reasonable income.

In order of climax, these have been (as you may have already guessed) the subjects of the four main divisions of this series of articles. And this as the fourth, is concerned particularly with the matter of the reasonable income, the most important (or at least the most fundamental) of all four.

When Figures Lie

Any comparison of employment in petroleum with that in other industries, however, must be prefaced with a brief consideration of three of oil's special problems. The first is that construction employment tends to show reduction when actually there may be an increase of permanent employment. The second is that the practice of contracting tends to show less than the actual employment or wages. The third is that continuous operation is essential in many divisions of the oil industry.

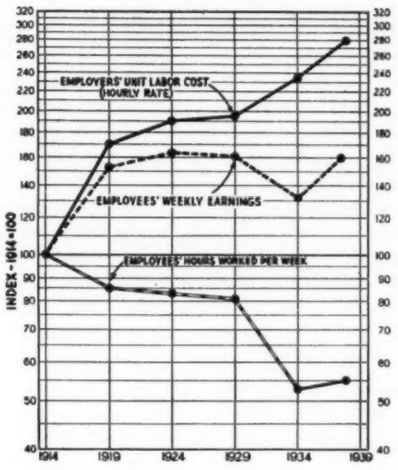
These forehanded footnotes suggest a true story about the sale of natural gas to domestic users in the pioneer days of the industry.

Not knowing how to control the flow of gas, the early companies merely hooked a pipe onto a cookstove, lit the gas, and let it burn from then on. One of the customers complained to the superintendent about having to burn his fire all the year, both summer and winter, as it made the house pretty hot in the summer.

The superintendent eyed him disgustedly.

"You can always raise a window, can't you?" he demanded.

In this case it is best to raise the window on our exceptions before we start.



Hours worked per week, weekly earnings and unit labor cost in petroleum industry for five-year intervals, 1914-1938

In this connection, as Mr. Anderson points out here in his report to the Temporary National Economic Committee, "Activities and employment associated with any industry or branch may be grouped in two classes: (1) the continuing work of operation and routine maintenance, and (2) the extraordinary work of new construction and rehabilitation. Unless payroll records reflect the segregation between these two classes of work, historical comparisons of employment are difficult to make. This difficulty is present when considering the petroleum industry."

Reported employment and payroll figures of the Bureau of Labor Statistics include only persons on the direct payrolls of a selected number of establishments or companies. If a company undertakes a special construction program with workers hired by it, their numbers and earnings will be included in the monthly reports. If the work is done by outside contractors, the employees and their earnings will not be reflected in the monthly reports. Thus an important amount of indirect employment provided by the petroleum industry is not shown in the bureau's figures.

As Mr. Anderson further notes: (a) Some of the reported employees were engaged in extraordinary construction work and were not due for retention after its completion. This extraordinary employment, however, causes distortions in trends quite different from those due to normal operating fluctuations. (b) Many companies have contracted substantial amounts of work to independent contractors whose workers are not on the reported rolls. Such employment naturally affects adversely the apparent measure of the total employment provided by these companies' operations.

This statistical negligence by statistical agencies exists despite a strong trend toward increased use by operators in the industry of contractors for both construction and maintenance work. In fact, the relative amount of such contract work is estimated to have jumped by 25 and 30 percent between 1929 and 1938. Principally, it has been aimed at the promotion of stability of employment for the construction and maintenance workers, and in this respect has worked greatly to their advantage.

Yet statistically, these workers do not appear on oil's payroll, although often they may outnumber the oil company workers in this same work.

For instance, 18 large companies were asked to report totals on their own employees engaged in all derrick and rig-building, drilling and directly allied activities, and the same for employees of contractors working under contract for these companies. The figures were as follows:

Year	*Company Employees*	*Contractor's Employees*
1934	7,782	6,058
1936	8,194	12,206
1938	8,499	9,428
Totals . . .	24,475	27,692

Here were nearly 28,000 well-paid oil industry workers not even reported on any payroll. And as the oilman reader well knows, rig-builders and drillers earn the highest hourly rates of any oil industry wage-earners. Rig-builder's and driller's helpers earn about the same wages as second-class mechanics. Neglecting to include large numbers of these highly-paid contract wage-earners in production totals has severely and adversely affected average hourly wage rates and average weekly earnings reported by both the bureau and the companies.

The third point to remember in considering petroleum's record, particularly as regards hours, is the fact that continuous operation is essential in some phases of the oil industry.

The importance of keeping the drill stem turning and the mud pumping in a valuable hole, the desirability of flow-

ing some wells without shutdowns that may make it difficult or wasteful to start up again, the need of making full use of the costly investment in a pipe line by 24-hour operation, and the economy and efficiency of continuous operation of an expensive refining plant, need no amplification for an oilman.

Many operations in the oil industry are different from those of most other industries and cannot be conducted like a factory. This fact has been largely responsible for the longer hours in the industry in the past. It has also made petroleum's task of adjustment to factory and shop schedules perhaps the most difficult of any industry's. Yet in the last 25 years oil has succeeded in doing this, to maintain currently work weeks well in line with even the most routine of industries.

Emergency Provisions

Oil has gone even further in providing beforehand for the inevitable emergencies that occur. Some companies have rules drawn up that protect the employee and his work schedule and pay under even the most extreme conditions.

For instance, one company provides that, "In event of an emergency, due to fire, runaway wells, pipe-line leaks or breaks, or Acts of God, when an employee is called for duty outside of his regular working hours, he shall receive pay for actual time worked, at one and one-half times his regular rate with a minimum of three hours' pay at his regular rate. In the event no work shall be required of an employee called out for such emergency, he shall receive pay for three hours at his regular rate. In any other event, an employee called outside of his regular hours shall receive at least four hours pay at his regular rate whether or not his services are required.... If in the event of an emergency a man should be required to work past his regular quitting time on any day, he shall not, on the next succeeding day, work more hours than will total 16 for the two days."

Perhaps the most novel of such company rules, showing the unusual care that the oil employer takes of the oil employee, is that which specifies: "Any employee who is required to work more than one hour past a regular mealtime shall, at the employer's expense, be supplied with a meal and afforded an opportunity to eat same, provided five hours shall have elapsed since his previous mealtime."

This information on special conditions and provisions in the oil business is helpful to a proper understanding of the industry's place on the ladder of comparative hours and wages. It is in no sense an apology for either earnings or time worked.

The point is that despite the fact that oil leads all other industry in higher wages and regular and desirable work schedules, its average might be even better if the jobs it creates and contracts were included. With all its high figures for wages and steady reasonable minima of hours worked, the oil industry is, if anything, better than even these outstanding averages represent.

Take, for instance, the matter of wages for common labor. A survey published by the U. S. Department of Labor in its Labor Information Bulletin for July, 1939, shows that as usual, petroleum refining leads all other industries with the highest rate of any, both in the highly industrialized north and also in the less-industrialized south and southwest where rates are lower.

How Oil Stands

The standing of the various leading industries in cents-per-hour wages for such labor is given as follows:

Industry	*Rate, North*	*Rate, South*
MANUFACTURING		
Petroleum refining	67.5	57.0
Iron and steel	59.5	44.0
Chemical	59.5	36.5
Meat products	58.5	49.5
Cement	56.0	40.5
Lumber	54.5	24.0
Paints	54.5	33.5
Auto parts	54.0	x
Glass	53.5	44.0
Paper and pulp	51.5	39.5
Machine	51.0	35.0
Leather	51.0	39.0
Brick and tile	48.5	29.0
Fertilizers	47.0	27.0
PUBLIC UTILITIES		
Street railway	52.5	31.0
Gas	50.0	35.5
Electric	49.0	38.0
Building, construction	63.5	34.5

x Not available.

Comparative figures for all manufacturing industries are 11.6 cents less than oil in the north and 22.4 cents less in the south. Petroleum's rate is twice that of some industries.

Even these figures do not tell the whole story. A private survey recently conducted in Texas (which normally would be included under the lower southern rate classification) shows an average of 67 cents per hour, or virtually the northern rate, for beginning labor in refining. What neither governmental or private survey shows is that some companies raise their laborers after 60 days', 90 days' or six months' employment—sometimes twice in the six months. It is a rare industry that increases its already high comparative rates so soon, and this even in the lowest wage classification.

Petroleum's practice of rapid promotions to slightly more responsible positions, such as yardman at a refinery or routine maintenance worker on a pipe line, also attracts employees having ambition and frequently better-than-average educational qualifications. This, in turn, carries on oil's tradition of a finer, abler type of worker.

In the skilled classifications, petroleum refining is equally prominent. Figures from the U. S. Bureau of Labor Statistics for August, 1939, show that refining is at the top in American industry with an average rate per hour of 97.5 cents. This is far higher than most other lines of endeavor, being almost double that of the textile industry, which has 47.9 cents, for example.

No other manufacturing industry has a higher average than petroleum refining, which is far above the all-manufacturing average of 63.9 cents per hour. Petroleum producing, with 88.2 cents an hour in August, ranked almost as high among non-manufacturing lines.

Refining Leads Industry

Or take industry's figures for 1938, last full year for which they are available. Here are the average hourly earnings for comparable industries:

Industry	*Average Rate, Cents*
Petroleum refining	97.9
Automobiles	92.2
Bituminous coal	87.8
Petroleum production	84.6
Rubber group	76.7
Iron and steel	75.8
Machinery group	72.5
Other chemicals	66.4
All manufacturing	64.6
Textile group	48.2

This high average for refining naturally includes some higher rates to bring up the wages for common labor and in the less skilled classes of refinery work. Rates of $1.05 and $1.10 an hour are found in several classifications in refining, and help place this at the top among industries insofar as hourly rates are concerned.

Refining also has its success stories to match even those of production. Take the case of the two young college students who had completed the course in chemical engineering at a well-known southwestern educational institution. The head of the department was so favorably impressed with their work that he tried to retain them as assistants in his department after their graduation. And by taking a reduction in salary himself, which he applied on their salaries, he kept them both the next year after graduation.

Realizing, however, that there was not much chance to get them an adequate income under the limited appropriation available for his department,

the chemistry professor listened to a friend of his, chemist at a large refinery, when an opening occurred in the plant. Although it was only for $75 a month, the professor advised one of the boys to take the job and he did so. A few months later the first student sent for the second, who also joined the company at $75 a month. Here the pair began a parallel rise in the refining department that is perhaps unequalled.

As the first boy moved up, the second moved up also to take the place just vacated by the other. Just 19 years after joining the company, the first became vice-president in charge of refining as well as a director of this large company; the second was made assistant general manager for refining.

High Hourly Rates

Although refining seems to have the edge over production in the comparative figures cited above, producing has several classifications that pay even more than those of refining. Rig-builders and drillers get the top pay of any hourly workers in the oil industry, with wages of around $1.40 an hour for the former and $1.54 for rotary drillers. Tool dressers, who received $1.17 an hour and several other classes of workers also are well up the line in hourly rates. As will be shown later, in weekly and yearly earnings, production exceeds even refining in totals paid its workers, to set a high for all industry.

While hourly rates are under discussion, a comparison of petroleum producing and refining with other large American industries is interesting. This is how oil stands when compared not only with normally comparable industries of a similar type, but also with industries of virtually all types (using figures for May, 1939, May being the month used for comparative statistical purposes since oil code days):

Industry	Hourly Rate, Cents
1. Petroleum refining	98.4
2. Printing (news, magazine)	96.6
3. Automobile	94.9
4. Building and construction	94.1
5. Petroleum producing	86.1
6. Rubber	85.4
7. Electric and gas utilities	85.2
8. Iron and steel	82.9
9. Printing (book and job)	81.7
10. Agricultural implements	80.8
11. Electrical manufacturing	80.1
12. Chemical	75.0
13. Railroads	74.0
14. Foundries and machine	73.5
15. Paint and varnish	71.1
16. Glass	71.0
17. Meat packing	69.9
18. Cement	69.2
19. Lumber and millwork	66.7
20. Furniture	66.1
21. Leather and tanning	63.8
22. Paper and pulp	63.6
23. Paper products	60.5
24. Wool manufacturing	59.7
25. Hosiery	54.8
26. Brick and tile	53.4
27. Silk manufacturing	52.0
28. Boot and shoe	51.6
29. Fertilizer	45.8

But production and refining have no monopoly on high hourly rates for oil workers. Take wages in natural gasoline manufacture, for instance.

A private survey conducted in Texas (which state is certainly not above average in rates) shows that a plant operator, beginning at 91 cents an hour is raised by some companies in six months to 97 cents and in 12 months to $1.05. A plant repairman enjoys the same schedule. An oiler averages about 81 cents to begin with, being raised to 87 cents in six months, and 94 cents in twelve. A plant fireman receives 1 cent less all the way through, with 80 cents, 86 cents, and 93 cents. A welder draws about 97 cents an hour.

As for monthly rates, a boilermaker receives $175, as do a loading rack man and chief electrician. A vacuum station operator draws $168.

In carbon black plants, plant repairmen get about 72 cents hourly to begin with, being raised to 77 cents in six months, and 83 cents in twelve. Operators have the same schedule, whereas tinners, checkers, and truck drivers receive about 77 cents an hour.

The pipe-line transportation division of the oil business has even more higher classifications than any of the others. A welder may average $1.12 an hour, as does a main-line engineer. A dayman makes $1.09 and an operator and gauger about $1 an hour. A line walker may make 97 cents an hour, and a watchman and welder's helper 88 cents, whereas a regular laborer draws 87 cents.

As for monthly rates here, a welder superintendent makes about $289, a district foreman $266, chief gauger $260, construction foreman $243, a first-class engineer the same, a welder foreman $231, and a machinist $202.

Whereas hourly wage rates and weekly earnings were quite different in production, pipe line, and refining under the varying conditions of 1929, the present averages under the uniform 36-hour weekly schedules of the integrated companies are approximately equal. There is now a substantial parity of hourly rates between the various branches for employees performing similar classes of labor, a condition made possible by the present uniformity of hours.

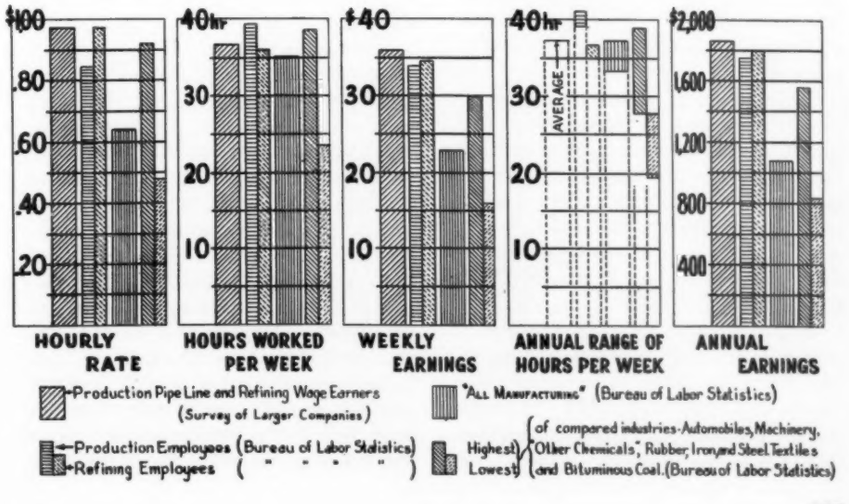
Hours Are Better

Not only in higher hourly wage standards but also in better hours of work for its employees has the petroleum industry taken the lead among comparable industries for the last quarter of a century.

In the matter of hours worked, two considerations naturally present themselves. One is that the men shall not be worked too many hours. The other is that they be given work for enough hours to guarantee a good total wage. If either of these factors is slighted, the employe, and with him the industry, suffers.

The progressive attitude of oil in the matter of reducing the once excessive schedule of the American worker has already been discussed historically. With maximum hours of labor now

Inter-industry comparison of working conditions: petroleum, "all manufacturing," and selected large industries



established by statute, there is little danger of any industry, least of all petroleum, offending in the matter of working its employees too many hours.

On the other hand, many an industry does not provide enough work to give all its men a full work week. Or it so poorly plans its year's operations as to incur avoidable slack or shutdown periods for which the employee pays in partial or total idleness.

The ideal condition, of course, is to provide uniform hours at a reasonable maximum average throughout the year. Oil meets both of these specifications to a high degree.

Take 1938, last full year for which figures are now available. In that year, working hours in the producing end of the business varied only from 39 to 40.5 hours per week. In refining, the fluctuation was between 35.3 and 37 hours. Yet two comparable industries were in some seasons able to offer their employees only 19.7 and 27.4 hours per week, respectively, bituminous coal varying from 19.7 to 28.0 and automobiles from 27.4 to 38.7.

Here are the limits of variation for the compared industries in 1938, based on monthly U. S. Bureau of Labor Statistics reports:

Industry	*Minimum*	*Maximum*	*Average**
Petroleum production	39.0	40.5	39.8
Petroleum refining	35.3	37.0	36.0
All manufacturing industries	33.2	37.4	35.3
Automobiles	27.4	38.7	32.7
Machinery group	33.3	37.4	34.9
Other chemicals	37.2	39.9	38.3
Rubber group	28.3	37.4	32.7
Iron and steel	27.7	35.6	31.3
Bituminous coal	19.7	28.0	23.5
Textile group	30.2	35.7	32.4

*Average of 12 monthly figures.

Since 1929, the hours worked per week in the larger oil companies have been reduced in the various divisions of the industry by amounts varying from 8.5 to 32 percent. As noted before, many oil companies continued the shortened hourly schedules prescribed by the oil code even after it became ineffective.

The attempt of petroleum employers to adhere to the spirit of the code's employment provisions is illustrated by the following comparison of former code hours and the actual hours worked in 18 companies for May, 1938:

Industry Branch	*Code Hours*	*Average 18 Companies*
Office, supervisory	40.0	39.5
Production	36.0	37.2
Pipe lines	36.0	36.8
Refining	36.0	36.1

Regularity High

In seasonal regularity of employment, oil scores high.

Contributing to this, most petroleum refineries now have tankage sufficient to store several months' stocks of refined products when necessary. This enables them to schedule their operations on a year-round basis that levels out year-round employment.

Industry	*Minimum*	*Maximum*	*Average**
Petroleum production	67.7	75.3	72.1
Petroleum refining	94.9	98.7	97.2
All manufacturing industries	77.0	86.0	81.9
Automobiles	43.1	96.0	68.2
Chemicals	88.9	100.0	96.0
Machinery group	65.8	82.6	72.2
Rubber group	61.9	75.3	67.6
Iron and steel	74.3	84.6	80.1
Bituminous coal	78.5	96.9	86.7
Textile group	80.7	94.1	88.7

*Average of 12 monthly figures.

Here good planning has relieved a once acute situation wherein refineries would be putting through large quantities of crude for part of the year and shut down or operating at a fraction of capacity for the remainder.

Also, the development of domestic fuel oil markets that enable the refiners to take advantage of present highly-controlled refining makes possible a year-round distribution for petroleum products. When cold weather comes, the plants change from gasoline to fuel oil (which gives a good market for poor gasoline crudes) and keep on going.

Of course, employment on pipe lines does not depend necessarily on the amount of oil pumped through the line. Employment in production is tied up closely with the price of oil, the situation of the particular company as regards crude supply, and the amount of capital available for exploration and drilling (which may or may not be a reflection of general business conditions).

Both production and refining show a remarkable seasonal regularity of employment, as reflected in comparisons for 1938 based on U. S. Bureau of Labor Statistics index figures. In refining, this varied between index numbers 94.9 and 98.7, whereas production shifted between 67.7 and 75.3. One compared industry ranged from 43.1 to 96.

Here are employment indexes, using 1929 = 100 and converting the U. S. Bureau indexes for manufacturing industries, which used 1923-25 = 100 to the 1929 non-manufacturing base:

Weekly Earnings Largest

Probably the two most striking features of the wage record of petroleum as compared with most other industries are the high weekly earnings and the unusual regularity with which such earnings are maintained throughout the year.

For example, the reported annual-average weekly earnings in 1938 in petroleum production were $33.94 and in petroleum refining, $34.92. These compared with a general average for all manufacturing lines of $22.84 a week. Comparable industries were all considerably below both production and refining, ranging from a low of $16.16 for the textile group to automobile's third highest of $30.14.

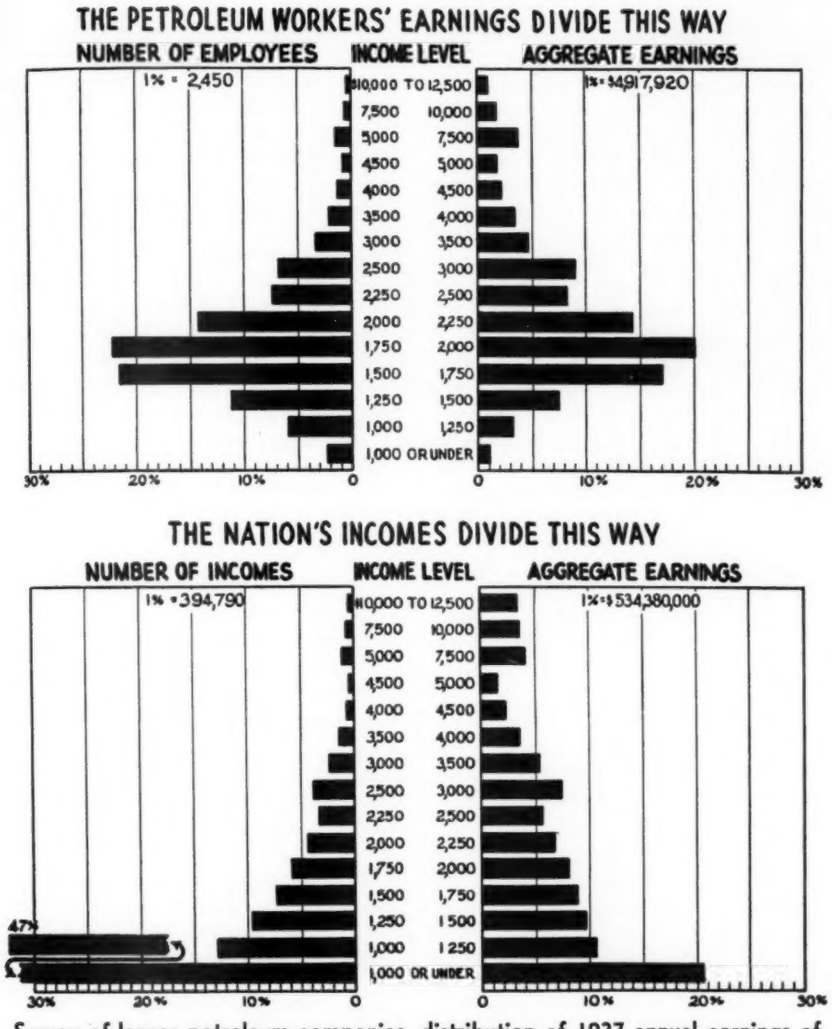
Here's how petroleum stands:

AVERAGE WEEKLY EARNINGS
1938

Petroleum refining	$34.92
Petroleum production	33.94
Automobiles	30.14
Machinery group	25.42
Other chemicals	25.16
Rubber group	24.61
Iron and steel	23.46
Bituminous coal	20.79
Textile group	16.16

The oil industry has long led other industries in annual-average weekly earnings. In fact, in no year from 1930 to 1938 did the reported averages in any of the compared industries equal or exceed those of production and refining. During the low year of 1933, when these divisions of the oil industry fell off to $27.55 and $26.67, respectively, all manufacturing declined to a low of $17.56.

The 1938 production and refining averages of $33.94 and $34.96 even topped the 1929 boomtime average of $33.26 for refining. These figures are in strong contrast with $27.54 for all manufacturing lines in 1929 against only $22.84 in 1938. Indeed, none of these industries but oil has reëstablished



Survey of larger petroleum companies, distribution of 1937 annual earnings of employees compared to reported distribution of national incomes

its 1929 high in average weekly earnings.

Such figures demonstrate the efforts of petroleum employers to restore pre-depression earnings to their employees in spite of simultaneous and substantial reductions in hours worked per week.

Office Workers Gain

As for office and supervisory workers, the 1938 weekly earnings of $47.79 were about 6 percent above those of 1929 whereas working hours had been reduced by about 8.5 percent to 39.5 per week in 1938.

Among production, pipe-line, and refining wage-earners' groups in total, the 1938 earnings of $35.80 were 5 percent greater than those of 1929 despite a cut of 32 percent in hours worked per week to 36.6 in 1938.

Furthermore, all these raises and restorations to pre-depression earnings should be considered in the light of the fact that the cost-of-living index for May, 1938, was only 84 percent of that of May, 1929. Thus a restoration in 1938 of 105 percent of 1929's weekly earnings means actually a restoration of 125 percent of 1929's real wages so far as purchasing power is concerned.

Consequently, the oil employee profits doubly—not only in nominal income but also in how much more he can buy for each dollar he makes. All this has been accompanied by his having to work much less time to earn more of the more valuable dollars.

As to regularity of petroleum's wages, comparison of the U. S. Bureau of Labor Statistics monthly averages for 1938 show that earnings in production fluctuated only between $34.48 and $33.41 per week, whereas those in refining moved only between $35.78 and $34.24. No other comparable industry even approaches this record as regards either average amount or regularity.

Such figures prove petroleum's outstanding position among all industries in higher hourly and weekly rates.

Total Earnings First

But how about the employee's total annual earnings? That, after all, is the real test of an industry's pay as far as the worker is concerned, and it is he who is most concerned.

On this point, the U. S. Bureau of Labor Statistics offers some interesting comparisons. In 1935, for example, the bureau's averages of actual annual earnings of employees reveal that petroleum refining workers made $1416 compared with only $1061 for all manufacturing. In 1933, petroleum refining employees averaged almost as high with $1300, although workers in all manufacturing industries were even further below it with only $833.

Using current Bureau of Labor Statistics, oil statisticians recently made further comparisons on annual earnings for 1938. The procedure used was to multiply the reported weekly averages for the year in each compared industry by 52. This shows petroleum even higher in the industrial earnings scale in 1938, with $1816 yearly for each worker in petroleum refining compared with $1188 average for all manufacturing lines. Other compared industries, using this same procedure, ranged from $1567 (for automobile workers) to as low as $840, or less than half as much as refining. Petroleum production also surpassed automobile manufacturing, maintaining an average of $1765 per worker to take second place.

These are all-industry averages as calculated with U. S. Bureau of Labor Statistics figures. Using the findings, however, of a special survey for 18 larger oil companies, the average annual earnings of at least big company employees are even higher. Accepting May, 1938, the reporting month, as average (as may well be conceded) the average annual earnings per employee were found to be:

Office and supervisory . . .	$2485
Production	1884
Pipe lines	1866
Refining	1845

Even more illuminating with regard to the oil worker's earnings is a comparison of income tax returns in the oil industry and in all lines.

Recently the National Resources Committee analyzed 39,458,000 individual and family incomes to show how they were split up among a series of income brackets. To arrive at comparable figures for the oil industry, petroleum statisticians a few months ago obtained information on the earnings of 240,527 petroleum industry em-

ployees. The striking results are graphically presented in the accompanying chart.

Several things immediately stand out to show oil's gratifying position in the matter of wages and salaries. For example, more than half of the national total of workers, or 59.63 percent, received less than $1250 per year whereas only 8.23 of the oil workers earned less than this. In the comfortable $1250 to $2000 range, only 22.63 percent of the national total is found, whereas oil scores 54.71 percent, or better than half. The $2000 to $3000 class includes 28.36 percent of all petroleum employees, compared with only 11.24 percent of the national total.

Showing even more effectively that oil pays a living wage, only 1 percent of the oil workers receives $1000 or less a year, against nearly 21 percent for all lines.

The figures on the oil incomes show, furthermore, a most healthy distribution of annual earnings. Nor are they preponderantly in favor of the salaried group. For instance, this group (which includes all salaried oil employees making up to $12,000 per year) averages only $2485 per employee whereas the wage earners in all divisions of the industry average $1870 a year, or about $156 a month.

Turnover Lowest

In the important feature of labor turnover, petroleum also ranks at the top among comparable industries.

Refining, indeed, shows the lowest "quit" rate (or measure of voluntary separation) of any compared industry. Only one other, iron and steel, shows any lower discharge and lay-off rates, and these are only slightly below refining's. However, this industry (iron and steel) increased 52 percent in the six-year period 1932-37 *to* an index of 96.3, whereas refining showed a gain of only 23 percent *from* an index of 100. Naturally, the tendency to discharge and lay-off is less when employment is rapidly increasing.

Here are percentages showing the low labor turnover record of the oil industry 1932-37 contrasted with other comparable industries, based on U. S. Bureau of Labor Statistics figures:

A very high continuity marks employment in the oil industry. Turnover, most conveniently defined as the number of replacements in percent of total hired per annum, runs in some cases as low as 1 percent, an average of 8.6 percent prevailing among the 245,900 employees of 18 larger companies supplying the most recent figures. Some companies report as low as one-half of 1 percent turnover in refining, most stable in employment of the main divisions of the oil industry.

Refining, in fact, rates almost twice as well in this field of satisfactory industrial relations as all other manufacturing industries. Figures recently compiled by the U. S. Bureau of Labor Statistics show that in 1938 petroleum refining had a separation rate of only 2.07 percent per 100 employees. All manufacturing, made up not only of comparable industries but also of many other types totaling 144 different lines, averaged 4.10 percent per 100, nearly twice as high.

Separations Reduced

Particularly noteworthy in this regard is the fact that whereas all-manufacturing's rate of separations has increased considerably since 1936, when it reported 3.37, refining's has been consistently reduced below both the 2.81 of 1936 and the 2.71 of 1937. All-manufacturing's figure this latter year was a high of 4.43.

All these data reduce to a statistical statement of this important fact: petroleum employees usually like their jobs, and their employers like the way they do them.

Sometimes, in fact, an oil company likes its organization so much that it keeps it intact even when the demands of the business would not strictly require it. For instance, a large oil company recently made a survey of the amount of work it ordinarily has to do and the number of employees absolutely necessary to handle it. The company learned it could, if necessary, carry on normally with about one-third fewer than its current force.

Instead of releasing the extra third, the company discarded the survey. It would have turned loose too many men and women who had given their best to the company and who were entitled to their jobs.

Industry	*Quit*	*Discharged*	*Lay-Offs*	*Separations*	*Accessions*	*Indexes of Employment Dec. '31*	*Dec. '37*	*% Gain*
Pet. Ref. . .	5.67	1.16	24.75	31.58	32.52	100.9	123.7	22.8
Automobiles	14.40	3.27	76.23	93.47	96.96	67.0	110.5	65.0
Machinery .	8.84	2.36	34.21	46.32	48.60	60.7	100.3	65.2
Iron	10.78	0.98	19.80	31.55	32.24	63.4	96.3	52.0
All Mfg. . .	10.78	2.18	34.45	47.42	50.41	72.0	94.5	31.5

In average length of service of its employees, probably no industry in the world exceeds oil. This is due both to the loyalty of the employees and to the opportunities that petroleum offers the ambitious worker to make the most of himself. A recent survey of 18 larger oil companies shows that 60 percent of their employees have 5 years of service or more. Of the group, 25 percent have from 5 to 10 years, nearly 17 percent from 10 to 15 years, and 11 percent from 15 to 20 years with their single company.

Here is the length of service in these companies, comprising almost a quarter of a million workers:

Completed Yrs. of Service	*Number Employees*	*Percent of Total*
0-4	98,215	39.94
5-9	62,053	25.23
10-14	41,690	16.95
15-19	27,031	10.99
20-24	11,206	4.56
25-29	3,481	1.42
30-34	1,396	0.57
35-39	648	0.26
40 and over	189	0.08
Total . .	245,909	

As some of the reporting companies pointed out, impressive as are these figures they are considerably below those of a few years ago, owing to the great recent growth of the industry and the decrease in hours since 1929 and under the oil code and the labor act. These have unduly increased the number of new employees hired in recent years.

Long Service Records

Figures from representative companies operating in all divisions of the industry show an average length of employee service of 11 years in one company, 11 years for another, 8 years for a third, and 9 for a fourth. However, the last company in pointing out the unusual additions to the ranks under the reduced hours program, oil code and labor act, reported that for those with the company in 1929 (when many companies began adding workers wholesale) the average service term is between 13 and 14 years.

Petroleum is among the leading industries in making awards to employees having noteworthy records of service, being nearly three times as active as industry in general in extending such recognition.

Some of the employees having the longest and most successful records, too, are those who made the poorest beginnings. Old-timers enjoy telling the one about the young laborer who came to work his first morning dressed in an "ice cream" suit of white flannels. The unfortunate choice of costume got him off on the wrong foot with the rest of the gang, and he had to bear the brunt of things all day.

To make matters worse, it began raining in the afternoon, thoroughly wetting the white suit before its owner could finish his work. That night, after some more good-humored roughhousing in the company bunkhouse, the newcomer prepared to turn in early. But he had forgotten to bring any night-clothes or cover, and since it was a little too cool to sleep in the raw, he was forced to go to bed in his white flannel suit. One of the boys lent him a quilt with a gaily-colored floral design on its cheap cotton covering, and he rolled up in it for the night.

Unfortunately, the colors in the quilt covering were not fast. When he waked up the next morning, he found the entire floral scene of the quilt had faded off onto his wet suit. Furthermore, he had neglected to bring a razor or comb.

The district superintendent happened to be on hand when the new laborer, colored like an Easter egg, and bristly and uncombed, showed up for work. The veteran superintendent turned to the foreman who had hired the fellow.

"You know," he said, "in my day I've seen lots of sorry specimens. But that guy there is the orneriest I've ever seen."

Less than twenty years later, the "orneriest specimen" was made vice-president of the same company.

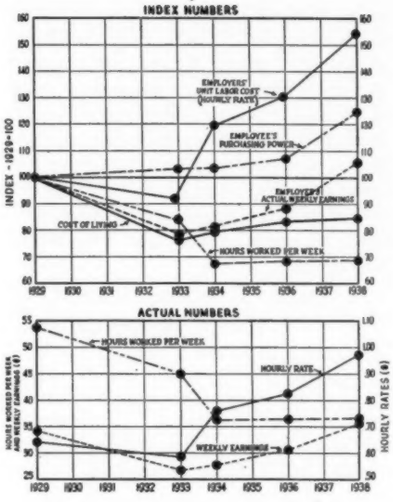
High Type Workers

Increasingly the oil industry is getting the highest type of worker, attracted by petroleum's better wages, more rapid promotion, and more extensive programs of employee benefits. Indeed, the industry has increasing need for this type as changes in operating technique (particularly in refining) make greater demands upon the knowledge and skill of the employee.

Between 1929 and 1937 these new processes have increased the barrel output and throughput per man-hour by 26½ percent in production, 11 percent in pipe lines, and 63 percent in refining. Yet despite this tremendous gain in output per man, the direct payrolls of the larger employers (where most of the improvements are in use) show no reduction in total annual earnings of workers in 1938 compared with 1929.

The changes, however, have drastically altered the composition of the working force. A smaller percentage of unskilled labor is now required, with a much larger number of semi-skilled and skilled workers.

For instance, in one large company the skilled workers in its refineries increased between 1929 and 1938 from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1929 1930 1931 1932 1933 1934 1935 1936 1937 1938

Wage, hours, and purchasing power of wage earners of the larger petroleum companies, 1929-1938 (May of each year)

27 percent to 52 percent of the total wage earner force. The number of semi-skilled decreased from 48 to 38 percent, and of unskilled, from 25 to 12 percent. In the same company's producing department, the unskilled workers decreased from 25 percent to 12 percent, whereas skilled labor increased from 21 to 29 percent of the total, and semi-skilled from 54 to 59 percent.

As a recent U. S. Government study, *Petroleum and Natural Gas Production*, points out: "Any change in the technical process of manufacture is sure to have an important effect upon labor requirements. In the aggregate, such changes are likely to cause a drop in the demand for manpower per unit of product.

"Direct-operating labor, for example, is particularly vulnerable to the onslaught of advancing technology and is the first to be affected by the further spreading of automatic control devices. Confirmation of this tendency is to be found in any modern large-scale plant where, without exception, operations are conducted by small labor forces of three or four men.

"The decline in unit labor requirements, however, may be expected to be more than offset by the expanding markets for an increasing variety of petroleum products, and total employment in the industry probably will increase. Indeed, the character of this trend is foreshadowed by recent preliminary figures showing a substantial increase in employment in petroleum refineries between 1935 and 1937."

And, as the report adds: "Although increased aggregate labor requirements may be expected to accompany impending changes in technique, there will also be important qualitative effects on the type of workers required." These give preference to the experienced refinery worker and tend to raise the responsibility and training requirements for the operating labor.

In lesser degree, these same tendencies manifest themselves also in the production, pipe line, and natural gasoline branches of the industry.

As this same government study points out: "The net result of progress toward more efficient oil and gas production on employment is not easy to determine. Such an appraisal requires consideration of what appear to be conflicting products of short- and long-time forces. An immediate effect on employment of wider spacing and fewer wells, for example, was a smaller number of jobs in drilling and oil-field development, whereas a long-time effort was more continuous employment for a longer period in individual fields than would otherwise have been possible."

Many with Contractors

The exact result of such technological advances, is difficult to run down in the incomplete statistics available. The most recent study, that of the 18 large companies, showed a drop in their total employment (excepting retail service stations as not concerned) from 217,004 in 1929 to 201,514 in 1938, or a loss of 7 percent. Yet because of the higher hourly rates, the decline in employees and in hours per employee reduced the total payroll almost none. The figure for May, 1938, was within $13,000 of the May, 1929, payroll, totals being $34,953,000 for this month in 1938 and $34,966,000 for the same month in 1929.

And whereas company personnel declined, workers in the production end of the oil business increased slightly. This was due to the contracting situation mentioned before that makes company figures in this department, at least, unrepresentative of industry employment.

Thus reports that show workers hired by contractors bring the total of production employment in 1929 for these 18 companies and contractors working for them to 47,606. This was divided 45,106 for the companies and 2,500 for the contractors. But in 1938 the total had swelled to 47,752, made up of only 38,328 for the companies but with 9,424 employed by contractors, a gain for them of nearly 400 percent. There is to be found more than 3 percent, or nearly half, of the apparent decline in employment, which

a superficial glance at the figures would not indicate.

As Little Buttercup so sagely observes in *Pinafore*, things are seldom what they seem. It's important to get and weigh all the facts.

Distribution of Workers

The difficulties of determining contracting employment make an accurate judgment concerning actual total employment in the oil industry a problem.

Even the American Petroleum Institute, statistical bulwark of the industry, has had a hard job arriving at the exact amount of such employment. In fact, A.P.I. statisticians in their latest figures on workers in the various branches of the industry, have contented themselves with an estimate, placing it at approximately 16,000 for drilling only.

The accompanying table shows the distribution of employees in the oil industry as of 1937, latest full-year for which reports were available:

Branch of Industry	*Source of Data*	*Average No. of Employees*
Drilling[1] and production:		
Salaried employees[2]:	Est. on Bureau of Mines 1935 Census	8,500
Wage earners[2]:	Bureau of Mines 1937 Census	121,371
Total		129,871
Contract drilling[1] total,	A.P.I. estimate	16,000
Natural gasoline plants:		
Salaried employees:	Est. on 1937 ICC Pipe-Line Report	2,666
Wage earners:	Est. on 1937 ICC Pipe-Line Report	26,933
Total		29,599
Marine transport, total:	Estimate	12,000
Refining:		
Salaried employees:	1937 Census of Manufacturers	15,268
Wage earners:	1937 Census of Manufacturers	83,183
Total		98,451
Marketing[3]:		
Wholesale, total:	Est. on 1935 Census of Distribution	124,798
Retail, service stations:	Est. on 1935 Census of Distribution	402,804
Retail, indirect[4]:	Estimate	182,000
Total		709,602
Grand total		1,006,052

[1]Company drilling employees included in drilling and production figures; contract drillers are employees of independent contractors, for whom little reliable data are available.
[2]Wage earners, classified as "workers" in Bureau of Mines reports, believed to include some clerical field employees; salaried employees estimated low to allow for this.
[3]Includes proprietors, except for indirect retail employment.
[4]Rough estimate of the number of wage earners selling petroleum products at the 182,000 country stores, parking lots, garages, and other non-service-station outlets for gasoline and lubricating oil. Estimated at one petroleum worker per outlet.

This distribution of employees does not consider at all the sizable number of workers for the various servicing companies.

For, increasingly, the oil industry depends upon the specialized and highly-technical services of one or more of these numerous organizations. Cementing of a well, gun-perforating its casing, shooting a hard formation or acidizing a non-porous one for a new well and cleaning out an old one, today generally require the summoning of these experts. Besides their thousands of workers, many others are engaged in geophysical and geological activity of various types including seismograph, torsion balance, magnetometer, gravimeter, soil analysis, core analysis, and aerial mapping work. Indeed, there are almost as many types of employers as kinds of employees in the modern oil industry.

Naturally, of course, most of the workers are still employed by the older types of employers. Major companies operating in all branches of the industry continue to be the largest hirers of employees of all kinds. Then there are the smaller oil companies, some of which are as fully integrated as the majors although confining their activities to a more limited territory. Next in the producing end of the business stands the independent operator, not only the employer of many but also creator of employment for many more if his wildcat hits. Sometimes also operating for himself and sometimes confining himself to drilling wells for others is the drilling contractor, who is making a steadily increasing amount of the industry's footage.

With such a variety of employers demanding such a variety of skills, the opportunities in petroleum for the ambitious worker are as unlimited as his ability. Probably no single industry utilizes the talents of more professions and trades, and certainly no other pays better for them.

25,000 New Jobs

A recent survey by the National Youth Administration in Texas shows that petroleum producing leads all other industries there in average weekly earnings, petroleum refining being third, only slightly below newspaper publishing. The survey concludes: "It is estimated that during recent years the oil industry has created each year at least 25,000 new temporary or permanent jobs in Texas. The industry offers the largest industrial employment opportunity within the state."

This might be repeated truthfully for most of the oil states.

Further tribute to the industry from the standpoint of labor was paid petroleum a few weeks ago by Isador Lubin, commissioner of labor statistics for the U. S. Department of Labor.

Taking part in the Temporary National Economic Committee's hearing on oil, the labor authority volunteered the comment, "I notice that at the present time conditions in the industry are very, very good, equal to and better than those that prevail in the large majority of industries in America: a higher wage rate, lower hours, more regular employment. I think the industry should be congratulated on that fact."

This, coming from a member of the national labor administration and particularly from the one most conversant with hours and wages, is high praise indeed. It is not likely that it would have been given had the industry not fully deserved it.

Only too often the employer gets blame instead of praise from both outside and within the industry.

A true story is told of a company head who had come up from the rig floor and who had never lost his very human point of view. When two of the company's bookkeepers stole a sizable amount of company funds, he blamed not them but his own company!

"It's the firm's fault," he declared, refusing to prosecute the men. "We should have had a better accounting system. The one we've got puts too much of a strain on anybody's honesty."

Admitting with Mr. Lubin that the oil industry has been successful in its industrial relations policy and that it offers its employees better hours, wages, and employee benefits, what about its prospects? For the worker anywhere short of retirement age is as keenly interested in that as in immediate returns.

Years of Plenty

Looking into the future, oil can count upon at least 15 years of comparative prosperity. Then perhaps the possibilities of declining reserves may play a larger part than now in determining whether the industry will continue its present type of operations or be forced to adopt other methods of recovery from other kinds of oil-bearing formations. But the oil business, which has always found an adequate supply of petroleum to meet the world's demands, may be relied upon to make every effort to continue doing so.

Probably no more conservative and yet soundly hopeful prophecy of the industry's next few decades can be found than that offered by U. S. Bureau of Mines technicians in the recent government publication, *Petroleum and Natural Gas Production.*

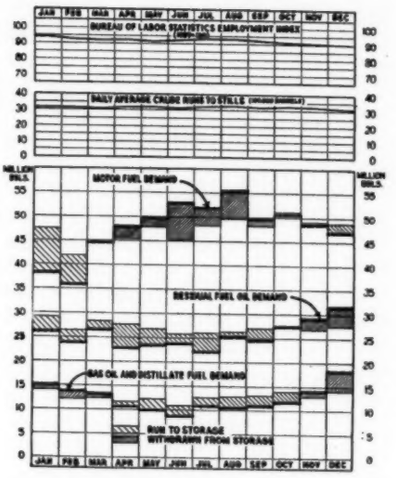
As these experts point out: "Both short- and long-time outlooks indicate that additional workers will be required in the petroleum and natural-gas industry. The increase will follow in part the expected continued growth of demand for motor fuel and lubricants and in part other factors, such as the shortening of the standard work week, tending to counterbalance a continued increase in output per man-hour owing to improved technology.

"For the next decade and a half the prospects appear fairly clear. Our proved reserves assure ample supplies for such a period and employment opportunities may be expected to increase, possibly at a somewhat slower rate than demand.

"The long-time outlook is clouded by uncertainties regarding reserves and the probable success of future efforts in exploration. This prospect, nevertheless, is one of growing difficulties in which technology finds it harder to overcome the handicaps of nature. The arrival of a stage of increasing cost and of greater human effort in production is forecast by experience in older producing fields.

"Finally, when output from wells undergoes major contraction and it becomes necessary to supply at least a part of the motor-fuel demand from alternative sources such as coal and shale, society must expect to devote an increasing proportion of its labor force to the task of mining its minerals from which the motor fuel is extracted. Although the developments that probably would accompany a scarcity of oil and gas from wells can be visualized to a certain extent, just when the period of diminishing abundance will emerge, only the future can disclose.

"Although the outlook is for increasing employment opportunities, the influence of technology in modifying the composition of the working force is expected to continue. The demand for unskilled labor in most branches of the industry—notably exploration, refining and pipeline transportation—is disappearing rapidly. The trend is now toward trained technicians and skilled and semi-skilled workers. . . .


JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
BUREAU OF LABOR STATISTICS EMPLOYMENT INDEX
DAILY AVERAGE CRUDE RUNS TO STILLS
MOTOR FUEL DEMAND
RESIDUAL FUEL OIL DEMAND
GAS OIL AND DISTILLATE FUEL DEMAND
RUN TO STORAGE
WITHDRAWN FROM STORAGE
MILLION BBLS.

Employment index, crude runs to stills, gasoline and fuel oil demand, monthly data for year 1938

"In drilling there is still heavy work for the laborer, but even here increasing proportions of skilled workers are required. For the bulk of the industry's labor force, youths with high school education or its equivalent are preferred by oil companies as new employees. Most of those accepted for employment, moreover, usually are put through an additional schedule of training at company expense. There is little hope for reëmployment of older, untrained workers who have lost their jobs in the industry."

Stake in Conservation

How closely the future of petroleum employment is tied up with orderly production is emphasized in the same volume: "Over the long run, the stake of the workingman is definitely in waste prevention and in efficient production control. When the essence is rendered from the many present conflicting forces, interests and opinions in the industry, it still appears that the larger the quantity of oil or gas made available for production by conservation engineering, the longer man will be able to work at the job of producing. Speaking from a statistical standpoint and ignoring the influence of factors that affect the status of individual workers (changing skills, for example), job security and tenure tend to improve as the life of engineering activities at different sites is extended."

But the average worker is not so much interested in the future of his industry as in his own personal future with that industry. For this reason we must consider not only where the oil industry is going but also where the employee himself is likely to go in that industry—or at least in that segment of it which his own company forms.

Although normally a business with a future might be assumed to offer each of its workers a chance to share in its prospects, such is not necessarily the case. For an industry that hopelessly stratifies its workers or habitually goes outside its own ranks to fill vacancies up the line might galley a man for life to the job in which he entered it.

Nothing can be more stultifying to the ambitious employee. Nothing will more quickly and thoroughly moth away his initiative than a sense of futility about going forward in the work he likes to do.

For, as the industrial relations expert quoted earlier in this discussion pointed out, the worker must have the feeling that he is growing and know that the door of advancement is held open to him if he has qualified himself to move on in. Fortunately, in both these particulars, petroleum ranks high among all industries. Not only does it offer the worker the necessary opportunity to learn on the job but also in many companies it insures him a chance to go on up in the organization if he can show its executives that he knows the job ahead.

It is, of course, obvious that qualifications must be the fundamental basis for advancement in any business that is to endure for long. Qualifications for most of the jobs in the oil industry mean not only native intelligence but also trained skill. Consequently, to the many who have not had specialized training before joining the ranks of oil workers, the opportunities for such training while on the job determine almost entirely the chances for individual progress.

Petroleum in particular (as was emphasized in the second article of this series) has long been active in affording such opportunities to its employees. But just how successful are these oil company programs in providing workers with the additional knowledge and skill needed to get ahead?

Skilled Workers

This question has for sometime interested one of the larger refining companies, and recently it decided to find the answer. Choosing for the study its

largest plant, the company's personnel department surveyed approximately 1160 jobs there that can be described by the broad term "skilled." These did not include office workers or higher supervisory personnel, but the various mechanical crafts and process operators necessary to carry out the intricacies of present-day refining. The personnel department set out to learn both where the men came from who filled these responsible jobs and where they acquired the ability necessary to fill them.

The findings were amazing.

Of the 1160 skilled workers contacted, 1046 came from the ranks of the unskilled laborers at this same plant. Only 114 of the entire number had had previous training fitting them for the places they now hold, and many of these were pioneers who set up the work in the plant. All the others, including many in the most difficult technical positions, had been given their opportunity to acquire the necessary special training right there on the job.

Breaking down this total by departments, the company found further that of 216 skilled operators—stillmen, housemen, topmen, firemen, etc.—in the distillation department, 212 had received their training in the plant. All but four of these had come from the company's own unskilled ranks.

On the cracking coils, 154 of the 159 skilled operators were trained on the job.

Of 31 boilermakers there, 29 had risen from the rank of helpers at the plant.

Twelve riggers out of 13 had learned their trades there, and 23 out of 40 machinists, 14 out of 26 carpenters, and 19 out of 30 welders had obtained their training in the plant.

In the gauging department, all 31 pumpmen and supervisors' jobs were filled by men who came up from lesser places.

In the lubricating oil department, all 40 skilled operators had received their training in this plant, as had 32 out of 49 pipe fitters.

In the treating department, 157 out of 162 skilled workers had come up from the refinery's unskilled ranks.

Twelve out of 14 electricians, 7 out of 8 skilled instrument repairmen, 5 out of 9 tinners, 4 out of 7 garage mechanics, and even 6 out of 10 railroad switchmen had learned their business at the company's plant under its policy of providing opportunities for special training to qualify its employees for better work.

The opportunities of learning on the job bring to mind the true story of a West Texan who picked up all he knows about the oil business just that way.

Got the Job Done

It was during the brawling, lusty days of Ranger, among the most fabulous of all the fabled boomtowns. Early one sultry July morning a man in his middle twenties—tall, rawboned and obviously from the country—appeared, hat in hand, at an oil company's bunkhouse and asked for "the boss."

The foreman stepped from the fringe of men outside the door and walked over to him, gonging a tin can expertly with a slug of his Brown Mule in passing.

"What d'ya want?" he demanded, wiping off his chin, with a hairy fist.

"A job," the stranger replied.

"Know anything about oil?"

"No," the visitor admitted frankly. "Been working on a farm all my life. But I stopped by an oil well the other day. I'd like to get a job on one."

The foreman sized up the young farmer. He was baked red by many Texas suns, trimmed spare by many Texas northers. But he was large-framed and muscular, and his directness and assurance created confidence.

"You look strong enough," the foreman conceded. "I'll try you out. Roustabout at 40 cents an hour."

The young farmer put his hat back on.

"When can I start?" he asked.

From that time on, the new roustabout never stopped. Night or day, he didn't know how to let up if he had a job to get done. And matching his driving ambitions and his unquenchable curiosity about every detail of the oil business was a tremendous endurance built up by years in the open. Very soon he was made a pumper, and in exactly nine months to the day from the time he joined the company, he was elevated to lease foreman.

It was while on this job that some eastern engineers came to the field to try out a new recovery process they had developed in their laboratories. The district superintendent to whom they were referred was not interested and shoved them off on his greenest foreman as the easiest way to get rid of them.

The young foreman, however, welcomed the chance to learn something about the new method from its inventors. Plunging into the task with the same interest and willingness to do any amount of hard work that had marked his days as roustabout, he soon knew almost as much about the process as its inventors. In fact, when the equipment sent down from the east would not function, it was the ex-roustabout instead of the engineers who tore it down and rebuilt it to make it operate.

The result was that when the easterners went back home and encountered other difficulties, they asked the company to send the young foreman up to help them. From then on he was a marked man with the company. Three years to the day after he entered its employ he was made district superintendent of one of the smaller districts. Production costs there had been the highest in the company. Not only did the ex-farm boy reduce them below what they had been, but in a few months he had reduced them to the lowest of any district in the entire company.

Promotion to a larger district where costs were high followed, and there again he cut them. A series of such successes brought him further promotion until on the first of January 12½ years after joining the company, the ex-roustabout was moved into the home office as general superintendent of the company's production department. In December of the same year, or exactly 13 years 4½ months after coming into the organization, he was made vice-president, a member of the board, and assistant manager of the production department. And this was the farmer who didn't know a kelly joint from a pool hall when he went to work!

Diamond to Desk

Rivaling this is the story of perhaps the youngest vice-president of a major oil company in the United States.

Also the product of a rural section, this young man offered as his principal marketable talent when he had to go to work his baseball playing ability. In fact, he was so good on the diamond that he had offers from the famous Cardinals as well as several minor league teams. But the oil business appealed to him even more strongly, and in 1923 he decided to desert the national pastime to join the labor gang.

His decision was a singularly happy one. From roustabout he jumped to production foreman, then to field superintendent, and not long after that to production district superintendent. Outstanding success there brought him the appointment within a relatively short time as manager of the company's affiliated pipe line company, and the next year, only 11 years after entering the oil business, he was made vice-president of the pipe line company and assistant manager of the main company's production department.

But he did not stop even here. Four years later, in 1938, or only 15 years after coming on the job as a roustabout, he was elevated to the vice-presidency of the parent company in charge of all its drilling, production, crude trading, and natural gasoline for the territory east of the Rocky Mountains. Not bad for a boy who, when he went to work, knew much more about socking a low one to left field or stealing "home" than he did about rockbits or sucker rods.

Such stories are, of course, exceptional. Naturally the men whose careers they represent are exceptional, or they would not have climbed so far so fast.

But the point is that these opportunities to learn and get ahead in the oil industry are available even to its greenest, most poorly-paid laborer—and the facilities for such a practical education while on the job are much more numerous, comprehensive, and accessible today than when our farmer left his farm or our baseball player put his glove away.

Promotion

Of course, there is no more necessity now than then for a worker to take advantage of them. Indeed, the employee today isn't allowed to work as long hours to try to get ahead on the job. But his time outside still is not restricted as to what he does with it, and he has a great deal more of it. There is, of course, no requirement that he employ these hours for anything but recreation, and there is no guarantee, should he make use of his opportunities, that he will necessarily rise any faster or go any further.

A man may work all his life as a machinist's helper and never make a machinist. On the other hand he may rise to a top-ranking executive of his company with no more training than he can get on the job. Much of it depends and always will depend upon the man. But the oil industry stands ready to do its part if the individual will make the effort.

One of the industry's most encouraging steps in this direction is the practice of many oil companies of filling vacancies solely from within their own organization. In fact, all the personnel managers interviewed in the preparation of these articles asserted, without exception, that perhaps the strongest factor in building employee morale is the rewarding of ambitious and qualified workers with promotion when an opening appears. Conversely, they agreed, nothing more quickly destroys employee morale than importing a man from another company or industry when a qualified man is already available down the line in the existing organization.

Indeed, one of the personnel directors even cited his own case in which he had worked up to a good job with one company only to quit it and join another as roustabout when the first company passed over fellow employees in filling higher vacancies.

How scrupulous some companies are in adhering to this policy is shown by a recent case. The vice-president in charge of production for a large company resigned to enter the oil business for himself. The assistant manager of production was made general superintendent to succeed him. One of the division superintendents was then moved in as assistant manager of production, and a district superintendent was moved up to division superintendent. A foreman was elevated to district superintendent, and a head roustabout was promoted to the foremanship. A gang pusher was made head roustabout. Then a member of a gang became gang pusher and a roustabout was added to the gang. In the end, the company had lost a vice-president and hired a new roustabout!

Not always, of course, can such a policy be followed. Sometimes the requirements of a specialized job make it necessary for the company to go outside its organization, but such exceptions currently are rare in the companies following this plan of promotion.

A corollary factor that helps employee morale is the placing of relatives of higher officials upon exactly the same footing in the organization as any other employee.

The personnel director of one of the integrated companies recently was waiting to hold an employees' meeting at a company plant when a worker sat down and began talking to him.

"How's Dave?" the employee asked, calling the president of the corporation by his first name.

"You mean Mr. Jones, our president?" the personnel director asked. "Why, he's fine."

When the man left, the personnel head inquired of the foreman as to who he was.

"That's the president's brother," the foreman informed him. "He's a machinist. Been here some years."

And this was the first the personnel director knew that the president even had a brother with the company.

Sometimes, of course, the fact that a worker is a kinsman of an official even hurts him, due to the executive's reluctance to show favors.

One highly respected member of a major company organization worked under a brother who was vice-president of the company. The executive was so concerned he might show some favoritism that the brother (who has been with the company 25 years) has not had a promotion in nearly 20. Meanwhile others who joined the company since he has, have moved past him through no fault of his.

Occasionally an oil employee recognizes the handicap of such a relationship and takes the bull by the horns. One was the son of a high official who first joined his father's company. For eight or ten years he showed considerable ability in his various jobs. But the unspoken feeling of his associates that he was getting by solely because of his father finally became too much for him.

He resigned and entered another large company where he had no relatives. His knowledge and talents made his advancement exceptionally rapid there, and today he is superintendent of production for the second company. In this case, gang resentment, perhaps unconscious but nevertheless strong, deprived their company of an executive who might have become a strong asset to it instead of to a rival.

How thorough is some companies' policy of recognition of merit in the ranks of workers and the opportunities this offers the employees are shown in a recent survey made by a leading California company among its own executive personnel.

Of the officers on its board of directors, the president began as a fireman in a pipe-line pumping station, whereas the four vice-presidents entered company employ as stenographer, salesman, chain man on an engineering gang, and office clerk. The other members of the board began as clerk, office boy, geologist, and civil engineer.

Of the men holding the 283 managerial positions existing in the organization, only 24 (or less than 10 percent) began in an executive or even a supervisory capacity. Of the 283 executives, 63 were clerks, 30 were service station salesmen including the vice-president and general manager of marketing operations, and 20 were regular salesmen including the assistant general sales manager and three district sales managers.

Included in the 283 were 10 draftsmen, 9 drillers, 7 roustabouts, 8 stenographers, 8 warehousemen, 5 laborers, 5 office boys, 4 messengers, 3 tank truck drivers, and among the technically trained personnel, 27 ex-engineers and 15 geologists. The head of the company production department was a geologist, and the two assistant gen-

eral managers had been drillers. The manager of one of the larger refineries formerly was a blueprint boy, the manager of another a laborer, and the head of the company's asphalt department, hall boy in a company office.

Even statistics such as these become a lively challenge to ambition when one realizes what they represent in opportunities.

Any number of success stories might be cited. Like that of W. L. Connelly, chairman of the board of Sinclair Prairie, who entered the oil business at the age of 14 as boilermaker's helper and was an independent producer at 19. Or of C. H. Lieb who rose from draftsman to president of the Standard Oil Company of Venezuela in 11 years, later went on to head the Carter Oil Company, and is now vice-president of both Creole Petroleum Corporation and Lago Petroleum Corporation.

Or of Ralph W. Gallagher who began as an odd-job boy and climbed to the management of all the Standard of Jersey's natural gas interests, and is now director and vice-president of Standard Oil (N. J.). Or of that great dean of oil executives, the late J. W. Van Dyke, who left school at 17 to take a job as pumper in the newly discovered Pennsylvania field.

Not only do these stories outdo Horatio Alger, but furthermore, they all happen to be true. The trouble with citing them, though, is that the average oil worker knows several others as good or better that happened to his own friends. In fact, a volume might be filled with them and still leave many good ones untold.

But because so many of its top-ranking executives have worked-up from the ranks, the petroleum industry enjoys an unusually close understanding between men and management. In fact, it is sometimes difficult for the practical oil executive to remember which side of the desk he is on when he has to make a decision. It is too much a habit to solve any problem presented him out of his lifetime of experience down the line as laborer, roughneck, pumper, pipe-line walker, or stillman.

The democracy of oil is full of stories showing the informality and friendliness of relations between oil executives and oil employees. In fact, it is a reflection of a feeling of many oil executives who have come up the hard way that they are just another employee in the same organization.

As *The Lamp*, official publication of the Standard Oil Company (N. J.), recently put it, "In this industry there can be no distinguishing line between the executive or manager and the man on the 'firing line.' In any phase of the industry the workman and his manager in the field or plant will be found together, working over a common problem.

"In the oil industry, more than in any other, the sheer force of practicability brings the workman through the various stages of the business into the highest executive position.

"This statement is well exemplified by the directors and higher officers of the company. Their own experience gives them a common background with the employee representative, a basis of mutual understanding which explains their continuing sympathy with and knowledge of the employee's problem."

Tradition of Loyalty

The democratic relations in the industry have been in no small measure responsible for the unusual loyalty of oil employees to their industry and their company. In the days before work hours were limited and minimum wages set, such loyalty was so common as to be taken for granted.

Yet how many new fields were discovered only because a drilling crew worked for beans and bacon to help a bankrupt wild-catter poorboy his hole down to a doubtful pay?

How many drillers, fighting a caving hole or heavy gas have seen their crews work 18 to 20 hours a day through stinging blizzards or a shadeless heat to keep the bit turning and the mud pumping?

How many a boll-weevil has taken off frozen socks in the welcome blast of the boilers' heat, and reviving his numbed feet with hot water, gone back for another twelve-hour tour because his boss was short-handed?

This is a loyalty that cannot be bought or sold because it is without price. It is a loyalty that cannot be defined by legislation or restricted by control because it surpasses both. It is a loyalty that has established a great tradition of service from the beginnings of oil until today. Finally, it is the principal ingredient of success for an industry that has come from nothing to second in the nation within the span of a man's lifetime.

As an oilman recently defined it, "This kind and degree of coöperation is not built merely upon mechanics, but presupposes understanding of objectives and policies. It is primarily a thing of the spirit. It is not built upon trading or compromising which leaves each side wondering if it has got the best or the worst of a bargain, but rather on a pooling of interests to bring out the best in the long run for all concerned."

Because this sense of mutual loyalty is general both with men and managements, the petroleum industry has had friendly and harmonious labor relations unsurpassed by any other industry.

Partnership of Petroleum

Not only has the "quit" rate been the lowest in all industry, but also strikes have been virtually absent.

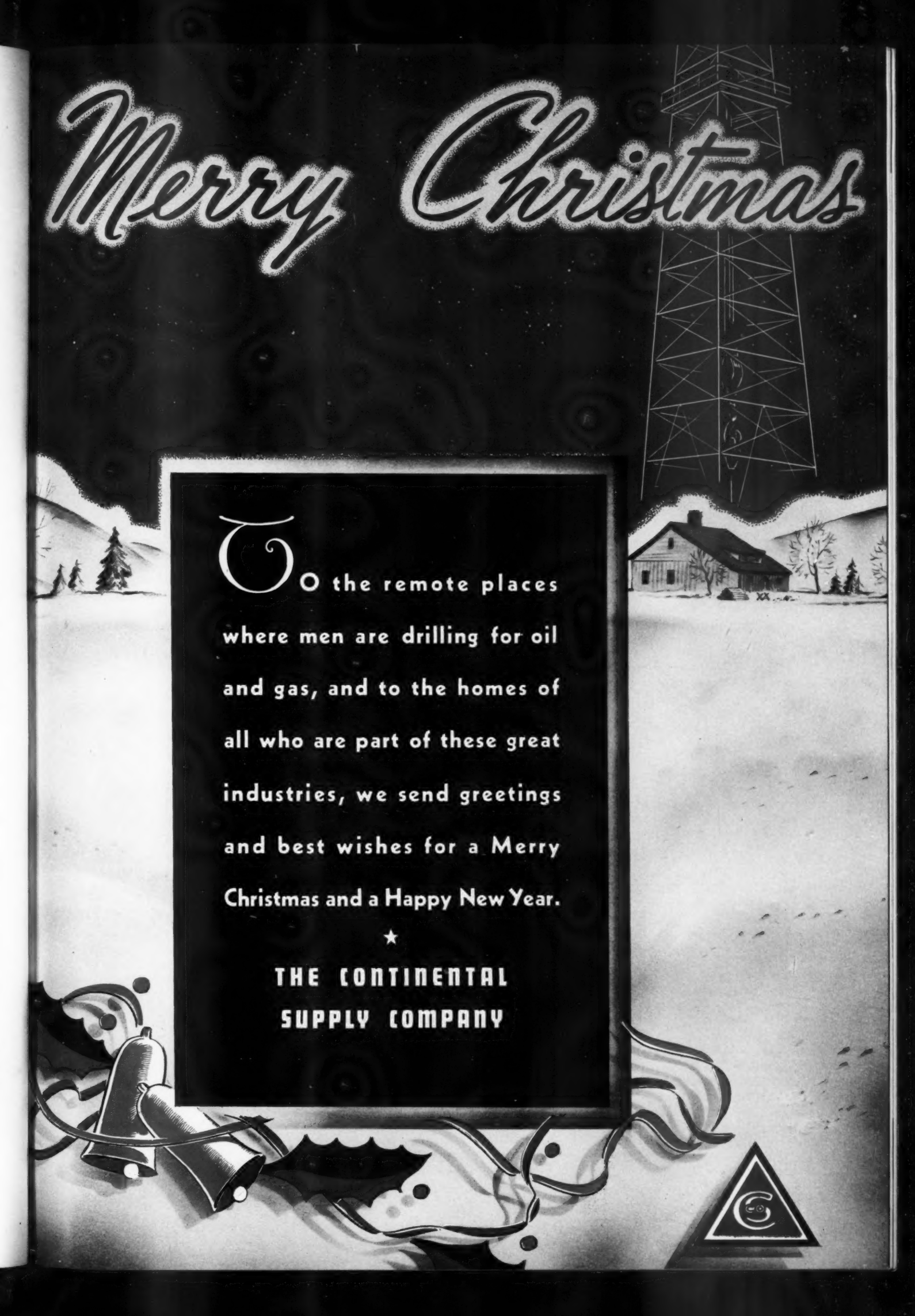
For instance, in 1936 there were only two refining strikes involving 301 workers, and in the first four months of 1939, one affecting 160 refining workers. Refining's four-year average of only 1.9 percent of its employees striking contrasts happily with 24.33 for automobiles, 29.41 for rubber, and 34.61 for bituminous coal. And as for the rest of the industry, production, pipe line, and natural gasoline have had virtually none.

Such a labor record is the working recognition by employee and employer of their fundamental partnership in the important enterprise of petroleum. The two are associates in a common venture and each profits only when their common undertaking succeeds.

As H. H. Anderson summed it up in his testimony before the economic committee, "These achievements of the industry in harmonious relations have come from the simple expedient of recognizing through the years—without pressure—the right of labor to a fair share of the proceeds of business, by minimizing for workers the effects of our economic cycles, and by predicating employment policies on the rule that no organization or industry can rise above the condition of those who comprise it.

"The industry's employment policies have been appreciated by a loyal and intelligent employee body, well aware of their preferment in the common effort to advance the standard of living. The combined effort and ingenuity of the industry's employees of all ranks have given the general public essential services, unselfishly conceived and faithfully rendered."

On that record, petroleum stands today. It is a record to which every member of the industry from the newest laborer to the oldest board chairman has been and is contributing, and of which each can be proud. With it for foundation, the industry builds into tomorrow with confidence that its future will be as great as its past and as important as its present.


Merry Christmas
To the remote places where men are drilling for oil and gas, and to the homes of all who are part of these great industries, we send greetings and best wishes for a Merry Christmas and a Happy New Year.
★
THE CONTINENTAL SUPPLY COMPANY

Steam Generation in the Natural Gasoline Plant

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

This important part of plant operation has become so commonplace that the underlying principles are too often neglected

By
ROY W. MACHEN, Superintendent
Hamman Exploration Company

THE generation of steam, although such an important part of plant operation in natural gasoline manufacture, is so often accepted as a commonplace function that many of the underlying principles are sometimes forgotten. It is believed advisable, therefore, to review certain fundamentals from time to time and it is to such a review that the present article is devoted.

Boilers should be constructed from materials selected for their ability to withstand the stresses and internal pressures to which they may be subjected. The vessel should be designed to have a safety factor of 4.5 to 6. Durability of the equipment and economy in evaporating qualities are two major factors to be considered in specifying workmanship and materials.

For its size, the boiler is one of the most expensive pieces of equipment in a gasoline plant. It is constantly called on to withstand heat and pressure, two of the most destructive forces encountered by metal. The boiler battery has been aptly termed the heart of the plant. The shutdown of the boiler system will necessitate a stopping of all other plant operations.

A boiler plant properly sized to provide an adequate and constant supply of steam without overtaxing the equipment has long since been proved to be the proper route to follow in designing a plant.

Steam boilers may be classified according to the method by which the water is heated.

Fire-Tube Boilers

Fire-tube boilers are divided into two classes, namely, (1) horizontal return-tube, and (2) horizontal fire-tube, or locomotive type. The characteristic feature of the fire-tube boiler is the group of flues that provide for the passage of the hot gases formed by combustion in the firebox through the main body of the water.

ROY W. MACHEN

received a bachelor's degree from Oklahoma City University in 1927—Employed for six and one-half years by the Peppers Gasoline Company as refinery clerk, refinery and gasoline plant chemist, and gas engineer — The last six years have been spent in the service of various independent refining companies as gas engineer, operator in high-pressure gasoline plants, refinery construction engineer, and superintendent of refinery operations—He is a registered petroleum and natural gas engineer —Recently he was promoted to superintendent by the Hamman Exploration Company.

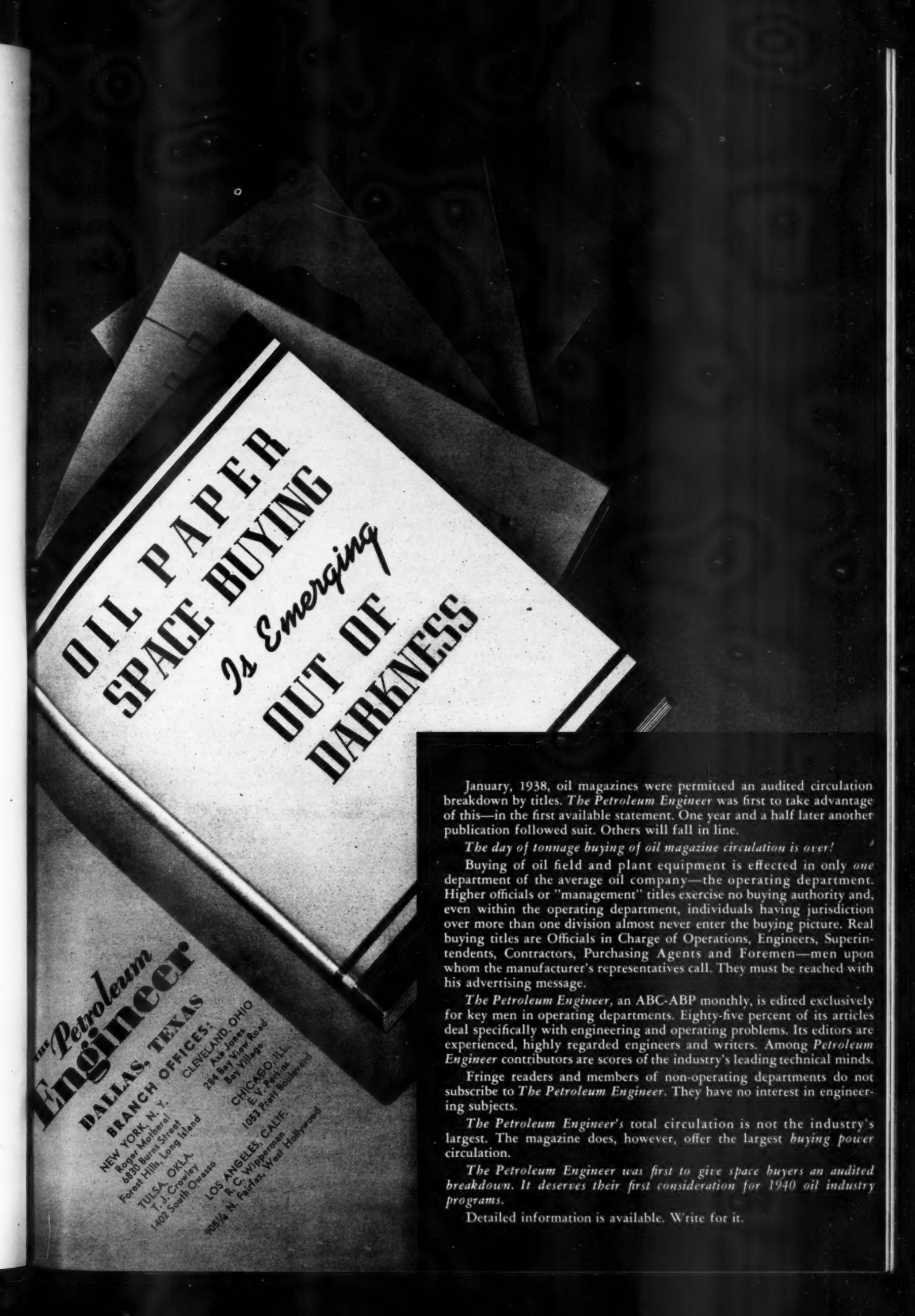
In the horizontal return-tube boiler, the combustion chamber is directly under the belly of the vessel and direct application of heat to approximately two-thirds of the entire outer surface of the vessel is quite often possible. The gases generated in the furnace pass to the rear of the setting, upward, and through the tubes back to the front of the vessel and exit through the stack.

The locomotive type, or oil-field boiler, is composed of a "firebox," the external shell of which is securely riveted to the "barrel." The firebox is composed of two shells that form a water chamber around the entire combustion space; each shell resembles an inverted U. The inner U forms a chamber of which five sides are of sheet steel. The sixth side (the floor) is left open for the installation of burners and to provide secondary air. The two sides, top, and front of the combustion chamber are tied to the outside U by means of staybolts. A heavy ring around the base of the two inverted U-shaped shells, termed the mud-ring, completes the tying together of the firebox and boiler barrel. The fire-tubes pass horizontally through the barrel and are tightly rolled into a flue sheet that forms the rear side of the furnace. The other ends of the flues are rolled into a flue sheet that forms the head of the rear end of the barrel. A steam dome is situated just back of the firebox on the upper side of the barrel for the collection of the steam generated. The steam dome makes it possible to supply a drier steam than would be provided without it.

The side walls, top, front, and flue sheet forming the inner shell for the combustion chamber receive heat by radiation from the combustion products. The gases generated pass through the tubes that are entirely surrounded by water. Upon reaching the rear of the vessel, the gases immediately rise through the stack to atmosphere.

Water-Tube Boilers

A water-tube boiler is considerably different from the fire-tube type. In this type boiler, the water is contained in the tubes rather than in a large cylindrical vessel. The fire is confined to a combustion chamber for radiant



January, 1938, oil magazines were permitted an audited circulation breakdown by titles. *The Petroleum Engineer* was first to take advantage of this—in the first available statement. One year and a half later another publication followed suit. Others will fall in line.

The day of tonnage buying of oil magazine circulation is over!

Buying of oil field and plant equipment is effected in only *one* department of the average oil company—the operating department. Higher officials or "management" titles exercise no buying authority and, even within the operating department, individuals having jurisdiction over more than one division almost never enter the buying picture. Real buying titles are Officials in Charge of Operations, Engineers, Superintendents, Contractors, Purchasing Agents and Foremen—men upon whom the manufacturer's representatives call. They must be reached with his advertising message.

The Petroleum Engineer, an ABC-ABP monthly, is edited exclusively for key men in operating departments. Eighty-five percent of its articles deal specifically with engineering and operating problems. Its editors are experienced, highly regarded engineers and writers. Among *Petroleum Engineer* contributors are scores of the industry's leading technical minds.

Fringe readers and members of non-operating departments do not subscribe to *The Petroleum Engineer*. They have no interest in engineering subjects.

The Petroleum Engineer's total circulation is not the industry's largest. The magazine does, however, offer the largest *buying power* circulation.

The Petroleum Engineer was first to give space buyers an audited breakdown. It deserves their first consideration for 1940 oil industry programs.

Detailed information is available. Write for it.

heat absorption. The gases pass back and upward over a baffle, then return to the front of the furnace and exit through a collection chamber to the stack. The travel of the gases is planned so that the application of heat is at all times to the outside of the water-filled tubes.

It is believed by some authorities that the steam from a water-tube boiler is drier than that from the fire-tube type.

Water-tube boilers are less likely to explode than fire-tube boilers and the consequences of an explosion are not so disastrous due to the small volume of water contained at any one time. This type boiler is more easily overloaded and is at its best when operating under a more or less constant demand.

Boiler Ratings

Boilers are rated as to size by the horsepower unit. According to the A.S.M.E. code, a boiler hp. is defined as the ability to evaporate 34.5 lb. of feedwater per hr. from and at a temperature of 212°F. into steam at the same temperature. In other words, when the feedwater enters the boiler at 212°F., 34.5 lb. of water must be evaporated per hr. per boiler hp. at atmospheric pressure. If the boiler gauge pressure is 125 lb., and the feedwater temperature is 212°F., the required evaporation is reduced to approximately 33 lb. per hr. per boiler hp.

Boiler Battery Subject to Abuse

A study of field practice as recommended by the A.P.I. and contained in "Oil Field Boilers, Code No. 2," will be of benefit to anyone who wishes to operate and maintain a boiler battery properly. The posting of a copy of the code for constant review in boiler houses where the oilfield type vessel is installed will aid materially in the reduction of unsafe practices. Strict adherence to its suggestions and recommendations will certainly minimize accidents and loss of property.

The outstanding features of the code are:

1. Frequent inspection of water levels by gauge glass and try-cocks.
2. Low-water-level instructions that should be closely followed.
3. Regular inspection of gauges and safety valves.
4. Proper "blowing-down" of the boiler.
5. Preparation for and inspection of boiler before firing-up to assure proper water level, draft, positions of entrance and outlet valves, clearance of furnace of any accumulated gases, and the correct routine for turning a boiler into the battery header.
6. Correct routine for taking a boiler out of service and for washing and cleaning.
7. Repairs to be made to the boiler and appurtenances, when and by whom.

Some of the most prominent abuses are:

1. Firing-up and placing in service too rapidly.
2. Blowing-down the boiler while it is still under steam pressure.
3. Cooling too rapidly by opening firebox and smokebox doors.
4. Ignoring safety precautions regarding blow-downs, sealing of steam and feedwater valves, disconnecting of fuel lines, and use of improper tools when repairing or cleaning a boiler.
5. Failure to clear combustion chamber of accumulated gases before firing-up.
6. Cutting boiler into battery header too rapidly or before boiler pressure is as high as the header pressure.
7. Pumping water into a "low-water-level" boiler before steam pressure has been reduced to zero; and refiring before the water level has been returned to normal.
8. Overheating caused by depositions of scale or oil from poor-quality feedwater.
9. Omission of proper inspection and attention of boilers at all times through gross neglect.

Boiler Feedwater

Boiler explosions are caused, generally, by overheating the plates. An insufficient amount of water in the boiler is quite frequently the cause of such weakening. When the pressure is suddenly increased by pumping water in a "low-level" boiler, the weakened plate is ruptured. Many times the reason for a low level can not be immediately ascertained and it is good and accepted practice to provide two distinct methods of supplying water to a boiler.

Scale and oil when present in feedwater will often form heavy insulating incrustations that will cause overheating of the plates. Not more than a protective coating of scale should be permitted. An insulating coat of scale only 1/32-in. thick will reduce the boiler efficiency by 10 percent. All oil should be removed from feedwater supply sources as its presence will lower the efficiency even if it is not present in sufficient quantity to collect and cause overheating.

The effect of feedwater heating on boiler efficiency is well worth considering in any installation. If the feedwater is heated to 210°F. prior to entering the boiler, it will require 13 percent less heat to convert it to 250-lb. (gauge) steam than it will to convert the same volume of water to steam from a temperature of 55°F.

Heating the feedwater to 200°F. precipitates the chemicals causing temporary hardness and any free oxygen contained in the water may be removed by venting. The boiler efficiency is increased due to the reduction of scale-forming substances in the feedwater and pitting resulting from the presence of free oxygen is eliminated. Hot-water feed eliminates local strains that are induced in the boiler when cold water is used and fewer leaks result.

Economy of Insulation

The insulation of boilers is an important factor in the conservation of heat input. An insulated boiler will show a fuel saving of more than 10 percent in many instances. When the boilers are housed and completely protected from the weather, the saving in fuel and heat input attributable to insulation will amount to considerably less.

In localities where the feedwater is high in saline content, the saving resulting from the use of insulation is more than offset by the difficulty of removing the insulation in making the constant repairs involved unless the insulating jacket is made in sections that can be removed periodically for boiler inspections and necessary repairs.

Properties of Steam

When steam is developed by the boiling of water at atmospheric pressure in an open vessel, no power is developed because the generated steam rises and mixes with the surrounding air as rapidly as it is formed. If the water is confined in a vessel and boiled, however, the steam generated, being unable to escape, exerts a pressure that increases as the volume of steam increases. The higher the temperature is raised, the greater the pressure in the vessel becomes.

The boiler battery in many modern gasoline plants is operated at or near 300-lb. gauge pressure. When operating at this pressure, it is possible to supply the distillation section with process steam at a temperature of approximately 420°F.

Steam is a colorless, dry, and invisible gas. Steam is water in a gaseous state. That white vapor commonly called steam is, in reality, steam in its first stages of condensation and the white color results from the multitude of tiny droplets of mist that have formed.

(Continued on Page 119)

(Continued from Page 116)

The specific heat of a substance is commonly regarded as the heat (usually expressed in B.t.u.) necessary to raise 1 lb. of the substance 1°F. in temperature.

The sensible heat content of 1 lb. of a substance is the amount of heat necessary to change the temperature of that quantity of material from one temperature to another by means of simple heating. The sensible heat content of 1 lb. of water that has been raised from 32° to 212°F. will be, according to Marks and Davis, 180 B.t.u., as the specific heat of water is 1.

The latent heat of a substance varies with the temperature, or pressure, at which vaporization occurs. After a lb. of water has been raised to its boiling point, its temperature will remain at the boiling point until the entire liquid body has been generated into steam. Although there was no change in temperature, the vaporization of this lb. of water has caused the consumption of 970 B.t.u., or more than 5⅓ times the amount of heat necessary to raise the same material from 32° to 212°F. This heat absorbed during the transformation of the liquid to a gaseous state is known as the latent heat of vaporization.

The total heat of steam is the sum of the sensible heat content and the latent heat of vaporization. At atmospheric pressure the total heat of 1 lb. of steam is 1150 B.t.u.

Steam occupies more space than the water from which it was generated. The steam volume is 1646 times greater than that of the water when boiling ceases at atmospheric pressure, i.e., 1 cu. ft. of water will generate 1646 cu. ft. of steam when evaporated at atmospheric pressure and 212°F.

Saturated steam is normally formed over boiling water and has the same temperature as the water that generated it. Saturated steam may be either "wet" or "dry," depending on the presence or absence of moisture in the form of a mist.

When saturated steam is removed from contact with the water from which it was generated and further heated to a temperature higher than that normally due to pressure alone, it becomes superheated steam. The increase in temperature of superheated steam is accompanied by an increase in pressure if the volume is kept constant. If the pressure is held constant, the volume increases with the increase in temperature.

The fuel consumption is increased approximately 6 percent when saturated steam at 250-lb. pressure is superheated 100°F. At the same time, the steam volume is increased by nearly 18 percent.

It is evident that by superheating 250-lb. steam 100°F. the evaporation required of a boiler is less than 85 percent of that required to supply the same amount of saturated steam.

It is a recognized fact that the use of superheated steam will result in more efficient lubrication of machinery, smoother and easier operation of pumps, less wear, and lower maintenance costs. The use of superheated steam permits the operation of the boiler plant at lower pressures for the procurement of a definite predetermined steam temperature.

Superheated steam is "dry" and the pressure drop in the steam headers from the boilers to the pumps is less by 6 percent than for saturated steam.

Historical Resume of the Petroleum Industry in Bolivia

TO 1916 oil concessions in Bolivia, South America, were granted in the same way as those for ore deposits, in accordance with the mining laws, says a release of the U. S. Bureau of Mines, in giving a historical resume of the petroleum industry in that country.

In 1916 a decree was issued placing all petroleum deposits in the Fiscal Reserve, and stipulating that oil concessions could only be granted in case the Government was accepted as a partner and given a royalty.

In 1920, Richmond Levering and Company, New York, obtained a provisional grant covering 7,413,131 acres, which was reduced to 2,471,043 acres after a geological reconnaissance was completed of the total area.

In June, 1920, the Bolivian Congress issued the first Petroleum Law, by which no concession larger than 247,104 acres would be granted and making the Government partner in every concession on a royalty basis. Under this law about 32,123,571 acres were granted to many private concerns.

The Standard Oil Company of New Jersey obtained from Richmond Levering and Company the transfer of the concession granted to them in 1920 and made a new contract with the Bolivian Government giving better conditions. The Standard Oil Company also bought many concessions from Bolivian owners. In the course of the years to 1936 and after geological studies of the entire area were made, the claims were reduced to about 741,313 acres, which covered the best zone from the Argentine border to Rio Grande in the Department of Santa Cruz.

The Standard Oil Company, besides making geological studies, drilled 30 wells in the most promising districts of the grant. These were drilled from 1922 to 1928.

Besides the Standard Oil Company, other companies made some geological explorations and drilled wells but none of these had any success. Among them were the Compania Aguila Doble, a Bolivian company that drilled in Cochabamba and the Compania de Petroleos de Calacato, which drilled two wells in the "altiplano" near the Arica-La Paz railroad.

In June, 1936, the Bolivian Government issued a decree that cancelled all claims that had not complied with the law of 1920. This left outstanding only the concession of the Standard Oil and Aguila Doble companies. The same year the Government created the fiscal organization Yacimientos Petroliferos Fiscales Bolivianos for the purpose of developing the oil deposits.

Again in March, 1937, the Bolivian Government issued a decree taking over the Standard Oil concessions in accordance with certain articles of their contract and turned their management over to Yacimientos Petroliferos Fiscales Bolivianos, which now is in charge of all developing and exploitation of petroleum in Bolivia.

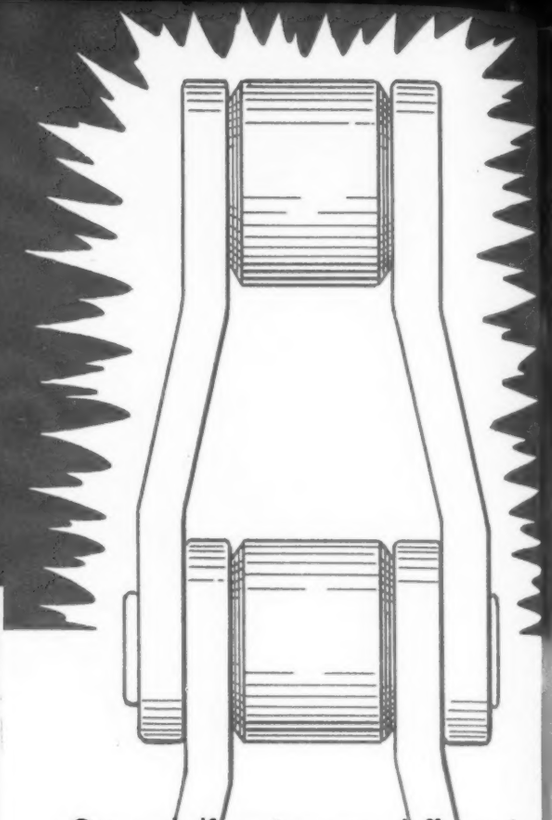
Today private concessions are not granted, but Yacimientos Petroliferos Fiscales Bolivianos is entitled to enter into partnership with private concerns but has not done so to the present.

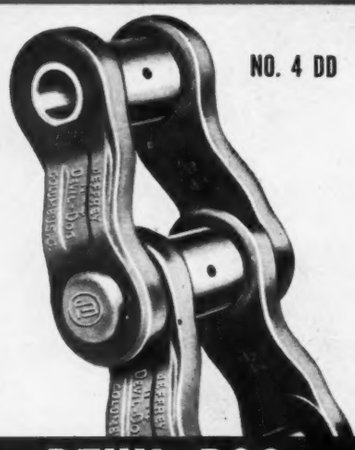
To date production has been confined to the fields of Camiri and Sanandita, whereas the districts of Bermejo, Camatindi, Macharati, Buena Vista, and Saipuru, although having potential production, are kept closed due to lack of economical means of transportation.

All wells that encountered producing formations are gushers and the ones of Camiri and Sanandita have been in active exploitation for almost nine years and still flow naturally. In these two districts there are small topping plants for the purpose of refining the crude produced. Under present development plans the capacities of the refineries are to be increased to fulfill the entire need of the country for gasoline, kerosene, Diesel oil, and fuel oil.

The Jeffrey STR CHAINS

background for ALL ROLLER TYPE CHAINS





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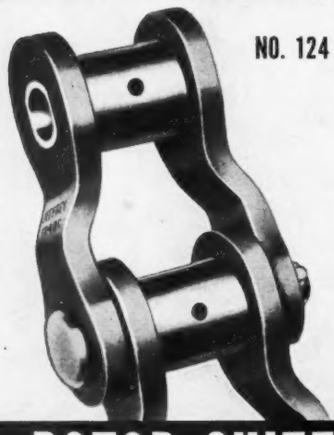

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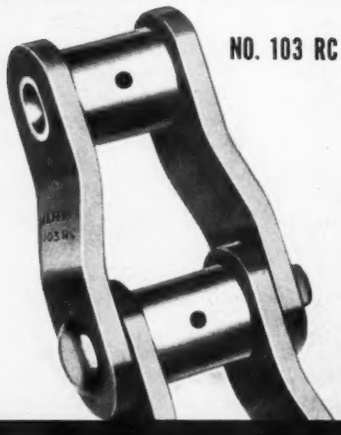

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ROTOR CHIEF . . . AVERAGE TO DEEP DRILLING

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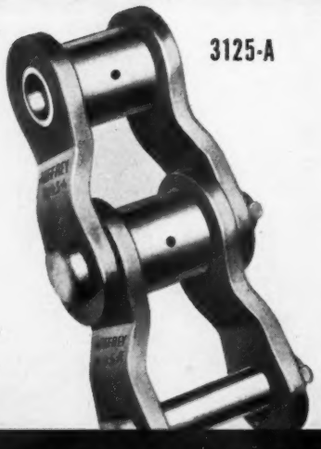

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RANGER . . . FOR DEEP — HIGH SPEED DRILLING

Over a half century ago, Jeffrey originated and patented the first all steel drive and conveyor chains with rollers turning on thimbles locked in the side bars and with pins articulating in the thimbles.

From this early invention (the Steel Thimble Roller chain) and from continued development during the past 50 years, came the present series of Jeffrey rotary drilling chains for oil well service.

With this enviable background of chain development Jeffrey oil well chains have a definite place in drilling today's deepest wells . . . with reserve stamina for the still deeper wells of tomorrow

Take advantage of Jeffrey's new technique in precision manufacture with the finest alloy steels in all parts . . . oil well chains with maximum strength and in available sizes to make their use a real economy.

THE JEFFREY MANUFACTURING CO.
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Characteristics and Requirements of Portable Well-Servicing Units[1]

In selecting engines for pulling-unit service the maximum horsepower is not so important as the actual horsepower developed at the peak of torque

By W. K. ATCHESON
Superintendent of Motor Transportation,
Southwestern Division, The Pure Oil Company

PERFORMANCE of well-servicing units differs from that of most other types of equipment that operate from an engine. In pulling rods or tubing it is necessary to start and to accelerate the load without changing gears until a stop is made to unjoint the rods or tubing; a condition imposed because there is no momentum built-up to carry the load while the gears are shifted, as in a car or truck. It is the same in running a bailer—as the load lightens and a change of gears is indicated, the unit must come to a stop in order to make the shift.

Fundamentally, all well-servicing units are similar. The ability of any servicing unit to move and to accelerate a given weight depends upon the power characteristics of the engine and the speed reduction provided in the gears of the transmission, chain sprockets, and the number of lines strung through the blocks.

The most popular engine used is the multiple-cylinder 4-cycle gas and gasoline engine of the truck and tractor type.

Experience indicates that there is a lack of understanding of the factors determining engine pulling power, such as torque and horsepower, and of their effect upon pulling-unit performance. The gasoline or oil engine is unlike the steam engine or electric motor, in that it cannot start from a standstill. It must be started by external means. A crankshaft speed of about 300 r.p.m. is required in order to develop sufficient power and momentum to turn the crankshaft steadily.

The primary function of a gasoline engine is to create a force tending to rotate a shaft. This force has been named "torque," which in its simplest terms means the twisting or turning force present in the revolving crankshaft of an engine, and is measured in "lb-ft." A lb-ft. is a force of 1 lb., acting in a circular direction about a 1-ft. radius. For instances, if you had a wrench 1 ft. long and applied a force of 50 lb. at the end, the torque developed would be 50 × 1, or 50 lb-ft.; and if you used a 2-ft. wrench with a force of 50 lb. on the end, you would have 50 × 2 or 100 lb-ft.

[1]Presented before the Petroleum Motor Transport Association, October 27, 1939, Tulsa, Oklahoma.

W. K. ATCHESON

while attending high school and after graduating served his apprenticeship in the tool and die factory of his father—When the World War began he enlisted in Naval Aviation and spent a year with the Northern Bombing Squadron overseas—When the war was over he went westward, working in mines, on railroads, and in garages, until he joined The Pure Oil Company at Columbus, Ohio, in May, 1926—After serving in minor capacities, he was made superintendent in November, 1927, serving as superintendent in the Northwest Marketing Division and later in the Central Division, which included marketing, production, refining, and pipe line, going to the Southwestern Division in January, 1930—He is a past president of the Petroleum Motor Transport Association, a member of the Society of Automotive Engineers, and the National Aeronautic Association.

In actual practice, when engine torque is being determined, mechanical or electrical means are provided to check the amount of torque at various engine speeds. A retarding force is applied to the flywheel; the amount of force applied is adjusted so that the engine speed neither increases nor decreases, but remains constant under the application of the force. The system of force is then in balance. This force, in pounds, which just balances the turning-force in the crankshaft, multiplied by the distance of 1 ft., through which it acts, is equal to the torque developed by the engine at that particular speed.

The engine torque, at various speeds throughout the engine speed range, is thus determined, and from it a torque curve is drawn as in Fig. 1 that shows the torque developed at the various engine speeds. It will be noted that the torque increases quite rapidly to maximum and then decreases gradually, the maximum torque being developed at 1000 r.p.m., in this case, although the maximum speed is approximately 3000 r.p.m.

If this engine was in a truck, the above condition would be readily recognized in climbing a hill. Suppose this truck had a gearing such that 3000 r.p.m. of the engine drives the vehicle at a speed of 55 m.p.h. Beginning to climb the hill, of uniform grade, at 55 m.p.h., the vehicle gradually loses speed until it travels at 30 m.p.h., a speed that is maintained during the rest of the ascent.

This means that at 55 m.p.h. (or 3000 r.p.m.) the torque of 140 lb-ft. would not permit this speed to be maintained. As the speed decreased, however, the torque increased, until at 30 m.p.h. (or 1600 r.p.m.) the torque of 176 lb-ft. was sufficient to maintain a uniform speed of climb. At this speed the force was then in balance.

Work

Work is done only when a force acts to move a body over a certain space. The amount of work accomplished, therefore, is measured by the product of this force times the distance through which it moves the body. The work of raising 10,000 brick, which weigh approximately 50,000 lb., 30-ft. in a building, may be done by a workman in 8 hr.; an elevator may be able to do the work in 20 minutes, and yet, in either case, the net result will be to

(Continued on Page 124)

IF PRESSURE CONTROL

Engineers and practical field-men always seem to "get along" with the Shaffer Engineering Staff —they speak the same language of Safety — Minimum Interference with Drilling — Savings of Time and Replacements that result in Low Costs.

Be sure to have a Shaffer Catalog before you when you plan for 1940, so that you can see how modern and efficient Shaffer High Pressure Drilling Equipment really is. There are important improvements as well as additions to the most complete and reliable line of Pressure Control Equipment ever offered to the Oil Industry.

Feel free to ask the Shaffer Engineering Staff for suggestions — you'll find them practical and profitable — and neither cost nor obligation is incurred.

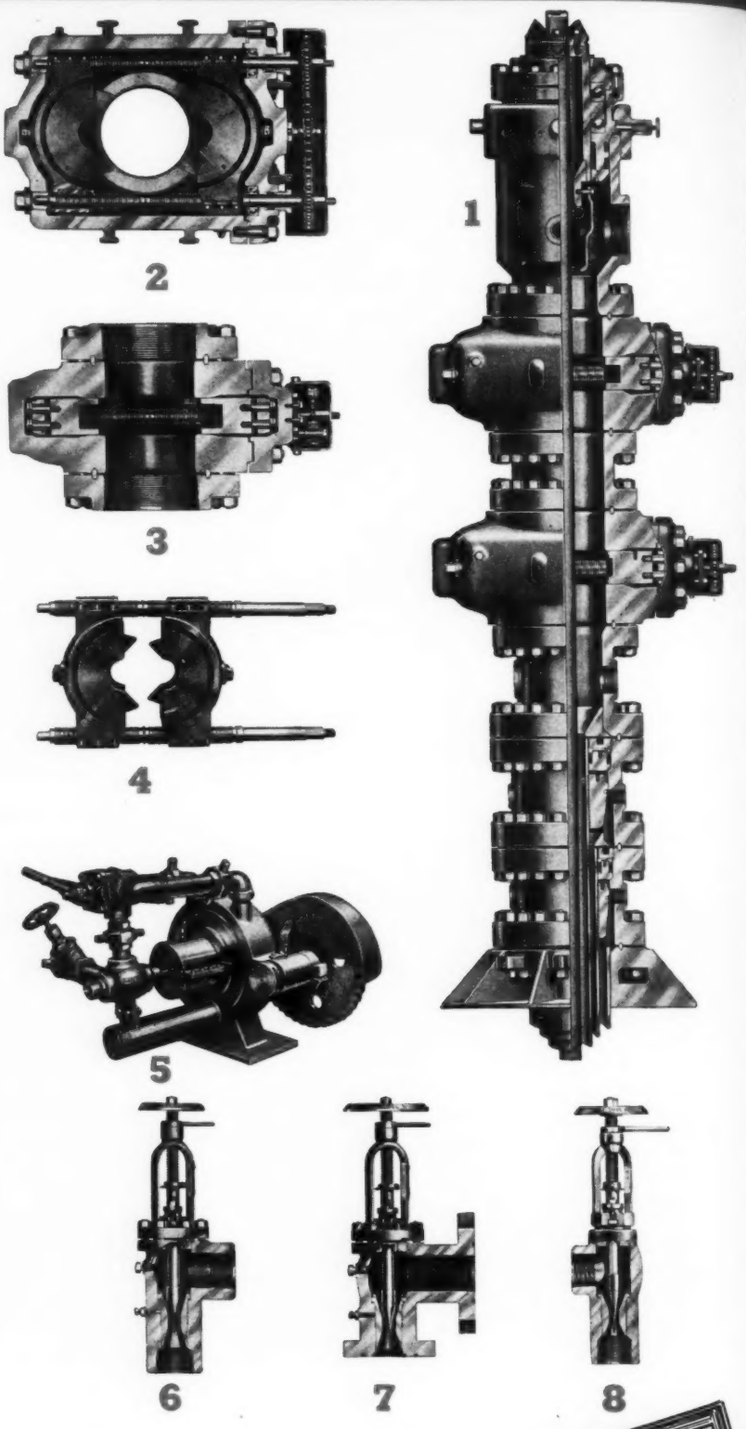
SHAFFER SAFETY HOOK-UPS

Shaffer High Pressure Drilling Equipment is available to meet any drilling condition, and by proper planning it is possible to combine economy, maximum efficiency and complete safety. The modern hook-up (1) shows how a one-size hook-up can be used from start to finish of a well where high pressure is likely to be encountered. A Shaffer Combination Rotating Blow-Out Preventer and Stripper is used above two Shaffer Type 38 Cellar Control Gates, the upper gate being equipped with rams for closing around the drill pipe. The lower gate is equipped with rams for a complete shut-off. This hook-up is ideal for wildcat wells or in remote areas where transportation of equipment is difficult.

With the casing program determined, or the number of strings of casing anticipated, the proper number of Shaffer Full Opening Spool Type Landing Heads are installed, and by merely adding guides of the proper size, when required, the drilling connections never need be changed in size or length.

The modern and efficient design of Shaffer Type 38 Cellar Control Gates is illustrated in views (2) and (3) where the positive method of sealing by the ram rubbers is shown; also the large, strong operating screws which bring the rams smoothly and evenly to the sealing-off position. A new effortless method of closing and opening any Shaffer Control Gate is the Shaffer Gate Closing Engine (5) which operates from the steam line and closes one or more gates with a speed never before possible.

Shaffer Self Centering Rams have been developed to meet the problem of centering small diameter drill pipe so that it is in proper alignment with the rams in larger bore Shaffer Cellar Control Gates. Protruding angular guides (see 4) engage the drill pipe and move it into a centralized position as the rams are closed. The guides telescope into the opposite ram block and permit the abutting faces of the ram blocks to seal perfectly. Self Centering Rams can be furnished for previous types of Shaffer Cellar Control Gates; details furnished upon application.



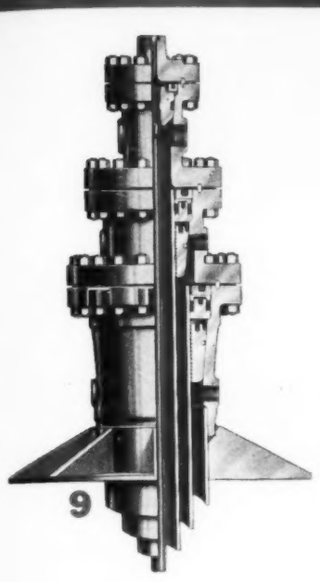
SHAFFER

Specialists in

HIGH PRESSURE DRILLING AND CONTROL EQUIPMENT
FISHING TOOLS THAT EXCEL

The new SHAFFER CATALOG which illustrates and describes Modern, Streamlined Equipment for 1940, will soon be off the press. Any oil man is welcome to a copy.. Ask for yours!

L IS YOUR PROBLEM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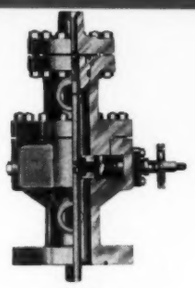
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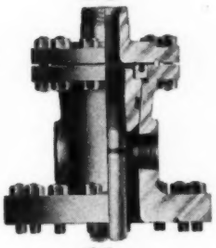
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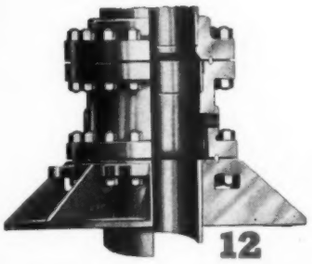
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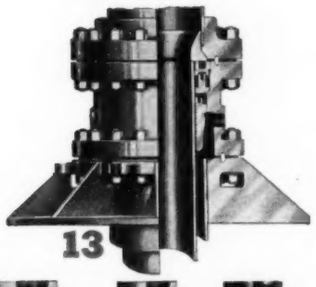
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CASING EASILY LANDED

The safe landing and packing off of casing is greatly simplified when Shaffer Full Opening Spool Type Landing Heads are used. Three strings of casing are shown landed, individually suspended and packed off by illustration (9); view (12) shows the full, unobstructed opening before the casing is landed, and (13) illustrates the simple, safe method of landing and packing off.

PRODUCTION HOOK-UPS

Shaffer Production Hook-Ups can be supplied to meet any of the varied conditions present in producing oil wells and to meet the preferences of any individual operator. Even under extremely high pressure, tubing can be pulled with ease and safety. The Shaffer Universal Tubing Control Head (10) serves as a blow-out preventer while drilling in and tubing the well. The Shaffer Type 35 Tubing Head (11) shows the tapered bore with the same inside diameter as the casing which permits running tubing catchers, and serves as a spider for the slips when running tubing.

Shaffer Adjustable Flow Beans are universally used for controlling the flow of fluid and regulating the pressure and rate of flow with extreme accuracy. A popular Screw Type is shown in view (6); the same style is made with A.P.I. Ring Joint Flanges (7). Another type which retains all of the flowing qualities of Shaffer High Pressure Flow Beans, but is designed for wells of moderate pressure only (at a correspondingly reduced price) is shown in illustration (8).

SHAFFER FISHING TOOLS

The safe, positive and economical results obtained from Shaffer Fishing Tools are due in large measure to the operation of a rental tool service for many years and to the knowledge thus acquired. Operators in far away locations can depend upon any Shaffer Fishing Tool as being simple in design, sturdy in construction, positive in action, and safe in service.

The ideal tool for left-handing or backing-off the string (when drill pipe is stuck in a tight hole with the tool joint box up) is the Shaffer Expanding Pin Tap (14). It provides a connection as strong as the rest of the fishing string, and has no equal for this service.

For cutting off casing, tubing or liners, the Shaffer Inside Casing Cutter (15) can be run on either drill pipe or tubing. Cuts smoothly without chattering, and is easily released and moved up or down the hole for repeated cuts.

Shaffer-Hamon Rotary Releasing Sockets are ideal for recovering drill pipe, casing, tubing or liners. This type (16) is recommended for use with right-hand tools.

Shaffer Sockets are used for recovering either loose fish or stuck fish. The Shaffer T. & T. Rotary Releasing Socket (17) is preferred with left-hand tools.

The Shaffer-Hamon Rotary Releasing Spear (18) is preferable when right-hand tools are used for removing casing or pipe; for setting liners; for holding or jarring jobs.

Shaffer Spears are the most readily releasing spears in use today. The Shaffer T. & T. Rotary Releasing Spear (19) is preferable with left-hand tools.

SHAFFER

Specialists in

HIGH PRESSURE DRILLING AND CONTROL EQUIPMENT

FISHING TOOLS THAT EXCEL

SHAFFER TOOL WORKS, BREA, CALIFORNIA • California Service Shops: Santa Fe Springs, Taft and Ventura
HOUSTON, TEXAS, 8006 Navigation Boulevard • OKLAHOMA CITY, OKLA., ACME OIL TOOL COMPANY, 1001 S.E. 29th Street
EXPORT SALES OFFICE: Shaffer Tool Works, 30 Rockefeller Plaza, New York, N. Y., U. S. A.

(Continued from Page 121)

raise 50,000 lb. a height of 30 ft. The amount of work performed would be 50,000 × 30, or 1,500,000 ft-lb. In general, therefore, 1,500,000 represents the work accomplished, 50,000 the force acting, and 30 the distance traveled.

In the discussion thus far no mention has been made of the time occupied in carrying out the work because the time element does not enter into the problem, as the amount of work performed remains the same regardless of the length of time required to perform it. In order to determine the ability of an agent to do work, however, it is necessary to estimate the "time rate" at which the work is done. Inclusion of the time rate of doing work denotes "power." The elevator does in 20 minutes what the workman does in 8 hr., or 480 minutes. The elevator is capable, therefore, of delivering 24 times more work per min. than the workman, and is to be rated as a 24 man-power machine.

Horsepower

"Horsepower" is simply a mathematical expression that defines the amount of pull per minute that can be developed by an engine at any given number of engine revolutions per minute. On an average, a horse can exert a pull of 100 lb. at a uniform pace of 240 ft. per min. for 10 hr. a day, without too great fatigue. This represents power, of 24,000 ft-lb. per min., but Boulton and Watt, in rating steam engines, and experimenting with the strong dray horses of London (about 1800), fixed upon 33,000 ft-lb. per min. as a convenient large unit of power. This value for horsepower has continued in popular use. As engine torque is defined as the turning force present at a distance of 1 ft. from the center of the crankshaft, the work performed is the torque in lb-ft. multiplied by the distance through which the force is exerted at a given speed. The distance in which it acts per revolution is:

2 ft. (diameter) $\times \pi (3.1416) = 6.28$ ft.

For example, in the engine that develops 180 lb-ft. torque at 1000 r.p.m., the amount of work exerted by the engine is equal to:

$180 \times 6.28 \times 1000 = 1{,}130{,}400$ ft-lb. of work or power per min. As 33,000 ft-lb. per min. equals 1 hp.:

$1{,}130{,}400 \div 33{,}000 = 34.25$ hp.

Formula:

$$\text{Horsepower} = \frac{\text{Torque} \times \text{engine r.p.m.} \times 6.28}{33{,}000}$$

Converting b.hp. to torque:

$$\text{Torque} = \frac{\text{b.h.p.} \times 33{,}000}{6.28 \times \text{engine r.p.m.}}$$

It is now understood that (1) horsepower expresses the amount of pull per minute that can be developed by the engine at any given engine r.p.m., and (2) it is torque that is the propelling force and is responsible for the acceleration and pulling ability of the well-servicing unit.

Always remember that the maximum horsepower developed by any engine at a given speed cannot be increased or decreased back of the engine. The speed can be changed back of the engine by different gear ratios. When the speed is decreased by a greater gear reduction, the torque is increased, and when the speed is increased by a lesser gear reduction, the torque is decreased, for the same horsepower. This statement is a fundamental fact and is often overlooked.

Pulling Ability

In a preceding paragraph it has been mentioned that pulling-unit performance differs from most other types of equipment that operate from an engine, because it has to start its load from a standstill, and accelerate it without changing gears during the pull.

In starting and accelerating a load from a standstill, full advantage must be taken of the maximum engine torque. Using a single line, at a line speed of only 25 ft. per min., over a 13-in. dia. drum, a high gear ratio of 80 to 1 results in an engine speed of only 587.2 r.p.m., which is much lower than when the maximum engine torque is developed, in this case around 1000 r.p.m. The friction clutch, therefore, has to be slipped temporarily until the line speed is reached that can be handled by the engine.

The following is very important, and is often overlooked: When the engine and clutch are in the best of condition, only about two-thirds of the maximum load, in relation to the maximum engine torque, could be lifted at a constant velocity from a standstill by slipping the clutch. This would be the same for each speed ratio, as the maximum pulling ability of each speed ratio is related directly to the maximum torque of the engine.

An engine, therefore, that develops its maximum torque at a low r.p.m., and maintains it as constant as possible throughout the engine speed range is superior for this type of work, as it will more nearly lift 100 percent of the load from a standstill. For this reason steam engines, electric and gas-electric motors are superior, as they develop their maximum torque from a standing start and hold it throughout their speed range. On the heavier drawworks they are adaptable when considered as stationary units. For portable units, their weight and flexibility are prohibitive. This leaves the multiple-cylinder engine of the truck and tractor type.

The nearest approach in using a multiple-cylinder engine to starting its maximum load in relation to its maximum torque is by considering the following points:

1. The use of more than one line, giving greater line length, strung through blocks, to give the engine a chance to accelerate and develop its maximum torque, by taking up the slack as tension is applied to the lines, giving a cushion effect. By adding more lines, however, there would be a sacrifice in work speed.

2. The use of an engine having large flywheels, and by accelerating the engine beyond the point of maximum torque. That is, if the maximum torque is developed at 1000 r.p.m. and the engine is accelerated to 1500 r.p.m., there would be sufficient energy stored in the flywheels to lift 100 percent of the load from a standing start by slipping the clutch. Using larger flywheels would mean, however, an increase in size and weight of the unit.

3. If the fluid clutch, or hydraulic transmission, is perfected so it can be used successfully, it will have many advantages over the friction clutch. The most important advantages are: will prevent the engine from stalling; will give it a chance to "slip" at a speed approximating that at which its maximum torque is developed. It will have a much better advantage, therefore, in starting a load and will provide a cushion effect in absorbing the mechanical shock and preventing it from being transmitted to the differ-

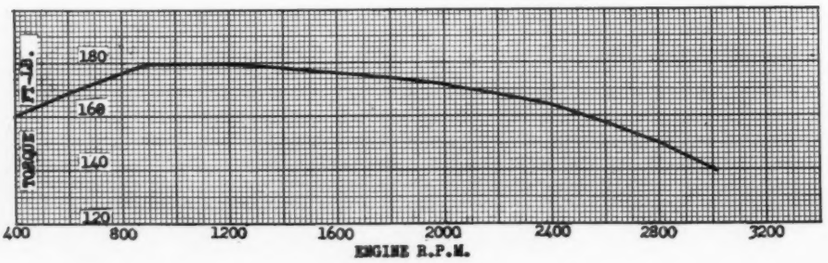
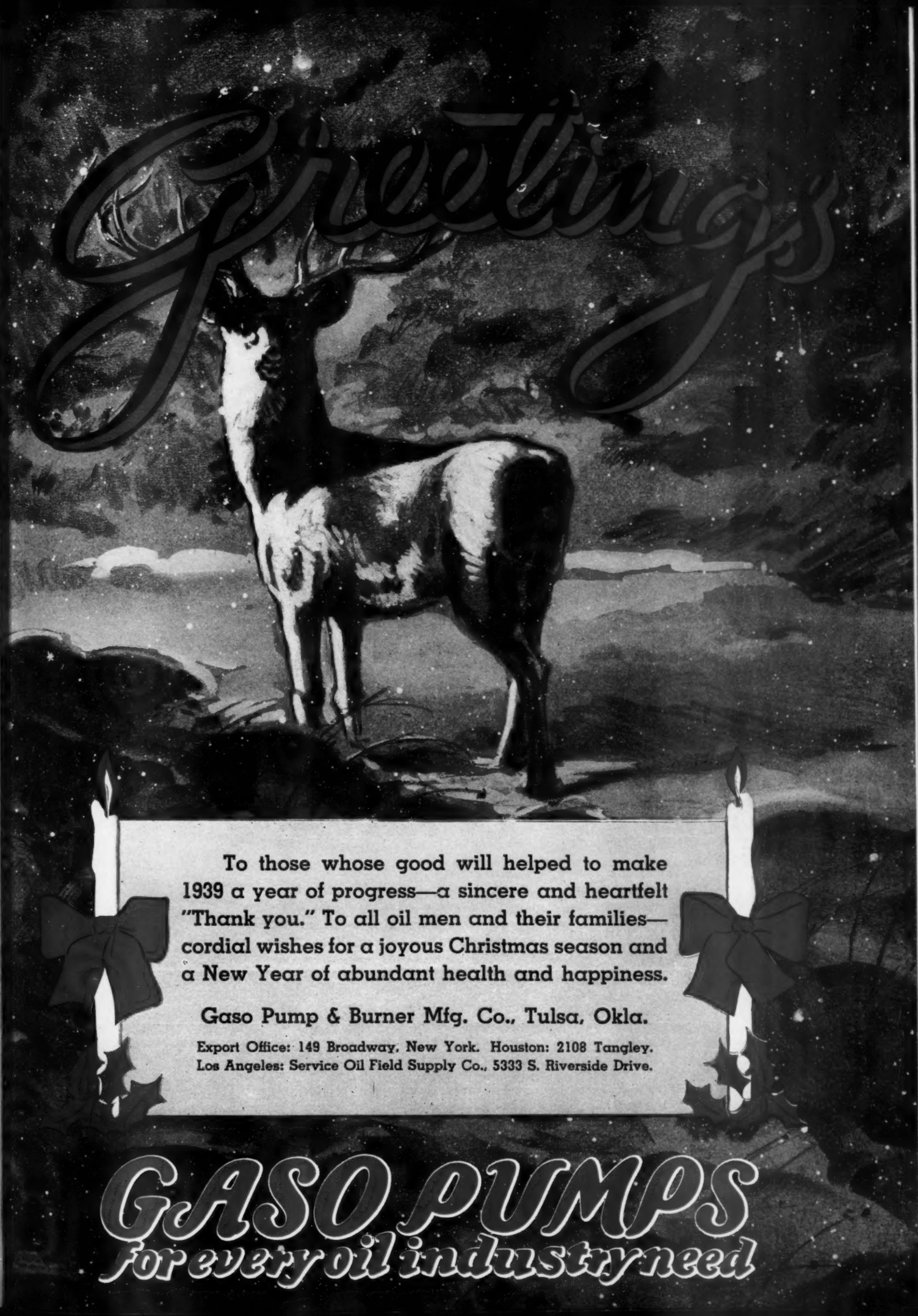


Fig. 1


Greetings
To those whose good will helped to make 1939 a year of progress—a sincere and heartfelt "Thank you." To all oil men and their families—cordial wishes for a joyous Christmas season and a New Year of abundant health and happiness.
Gaso Pump & Burner Mfg. Co., Tulsa, Okla.
Export Office: 149 Broadway, New York. Houston: 2108 Tangley.
Los Angeles: Service Oil Field Supply Co., 5333 S. Riverside Drive.
GASO PUMPS
for every oil industry need

ent parts of the machine and to the surface and subsurface equipment.

Line Pull

The engine torque is transmitted through transmission gears, chains and sprockets to the drum on which the line is spooled. This force is called "line pull," which determines the pulling or lifting ability of the unit in lb. The maximum pulling ability of any pulling unit in any given transmission speed is determined by the total amount of gear reduction in that speed. When determining the maximum pulling ability for the average unit, the maximum starting ability is of more importance, as it is approximately two-thirds of the maximum pulling ability. In determining the maximum pulling ability the efficiency of the motor should be considered as 0.75 because of the losses created by the motor accessories, transmission gears, chains and sprockets.

Formula: Pulling ability in lb. =

$$\frac{\text{Maximum torque} \times 12 \times 0.75 \times \text{total gear ratio}}{\text{Rolling radius}}$$

in which:

Rolling radius, or drum radius = the leverage, i.e., the distance from the center of the drumshaft to the surface of the drum.

Starting Ability

Two-thirds of the motor efficiency of 0.75 used in calculating pulling ability = 0.50.

Formula:

$$\text{Starting ability in lb.} = \frac{\text{Maximum torque} \times 12 \times 0.50 \times \text{total gear ratio}}{\text{Rolling radius}}$$

The starting and pulling ability of a given unit can only be increased in the following ways:

1. By the use of a large engine developing greater maximum torque.
2. By a loss of speed through one of the following: Greater gear reduction in transmission, chains and sprockets, or by use of additional lines in blocks.
3. To increase starting ability only: By the use of an engine that develops its maximum torque at a low r.p.m.

Engine Speed to Drum Speed Equals Line Speed

In order to translate engine speed in r.p.m. to line speed in ft. per min., it is necessary to take into account not only the speed of the winch drum in r.p.m., but also the distance in ft. per min. covered by the line as it is spooled or unspooled on the drum.

For example: A unit is pulling tubing in fourth gear, with a 1 to 1 ratio and a 3.2 to 1 bevel gear in the take-off box and a 6 to 1 winch drum ratio. At a motor speed of 1000 r.p.m., if we eliminate consideration of gear efficiency, the winch drum speed is equal to:

$1000 \div 1 \times 3.2 \times 6 = 52.08$ r.p.m.

Formula:

Winch drum speed, r.p.m. =

$$\frac{\text{Engine speed, r.p.m.}}{\text{Total gear ratio}}$$

Total gear reduction =

$$\frac{\text{Engine speed, r.p.m.}}{\text{Drum barrel speed, r.p.m.}}$$

If the unit had a 13-in. dia. barrel, the "rolling radius" would be 6.5 in. As the drum is revolving at 52.08 r.p.m., line travel in ft. per min. may be readily calculated.

Formula:

Line speed =

$$\frac{6.5 \times 2 \times \pi \times 52.08}{12}$$

= 177 ft. per min.

This speed prevails during the first wrap on the drum. If ¾-in. line is being used, the "rolling radius" will increase ¾-in. on the second wrap and on each wrap thereafter. For instance, if the rolling radius is 6.5 in. for the first wrap on the barrel, then for the second wrap the rolling radius would be 7.25 in., and the line travel in ft. per min. would equal:

$$\frac{7.25 \times 2 \times \pi \times 52.08}{12}$$

= 198 ft. per min.

To find drum barrel speed in r.p.m., when line speed is known:

$$\frac{\text{Line speed in ft. per min. at unit} \times 12 \text{ in. per ft.}}{\text{Barrel radius} \times 2 \times \pi}$$

The general formulas for converting engine speed in r.p.m. to corresponding line speed in ft. per min., and vice versa, are as follows:

Line speed in ft. per min. =

$$\frac{\text{Engine speed in r.p.m.} \times \text{rolling radius of drum in in.} \times 2 \times \pi}{\text{All ratios in that gear} \times \text{drum ratio} \times 12}$$

Conversely:

Engine speed in r.p.m. =

$$\frac{\text{Line speed in ft. per min.} \times 12 \times \text{all ratios in that gear}}{2 \times \pi \times \text{rolling radius of drum in in.}}$$

Line and Derrick Capacity

Line and derrick capacities are very important and should not be overlooked in any operation, as they have a bearing in working out the performance ability factor of the unit. The maximum load weight for the operation should stay within the maximum safe working load of the line and derrick and if it goes over, additional lines should be used. As additional lines are torque multipliers, they are also speed reducers as well as load reducers on the derrick. In reducing the load on the derrick, if the load on a single line was 9000 lb. there would be a 9000-lb. pull, or a total of 18,000 lb. on the derrick. By using two lines there would be 9000-lb. load and one-half the pull or 4500 lb., a total of 13,500 lb. on the derrick.

To obtain the same work speed that prevailed before additional lines were used would require increase in speed of the winch drum: 2 times the r.p.m. of the winch drum when 2 lines are used, 3 times when three are used, and so on. This increase in r.p.m. would be obtained either by a decrease in ratios of transmission or chain sprockets or by an increase in engine speed. Increase of the drum speed depends upon the power characteristics of the engine, as line pull is directly proportional to engine torque. For the same horsepower delivered by the engine, the drum speed can be increased by substituting a smaller gear reduction, a corresponding decrease in torque resulting, or the drum speed can be decreased to obtain an increase of torque by means of a bigger gear reduction. This statement is a fundamental fact and is often overlooked. Drum speed, therefore, could only be increased to the point where the engine torque is in balance with the load being lifted. To increase the drum speed in proportion to the number of lines would mean a very large motor or motors to develop the required amount of torque. In addition, heavier parts would be required to take care of the additional torque and weight, thus increasing the cost and difficulty of transportation.

In most instances when additional lines are used, the least possible number is employed. It would be better to sacrifice speed on the heavier operations than to have the heavier units of power. It is necessary, too, that the different operations, such as the pulling of bailer, rods, tubing and combined tubing, rods and fluid, be classified as to which one or ones are performed more frequently during the life of the unit. The performance abil-

Another New Regan Product

104"

NARROW TYPE H TRAVELING BLOCK

5 - sheave - 400 Tons

6 - sheave - 500 Tons

Dead Load Capacities

This Traveling Block provides a compact unit in the 104" size so that it can be operated with ample clearance in the derrick where large quantities of drill pipe are stacked. It is similar in construction to the Regan 121" Traveling Block. It is completely enclosed with streamlined safety guards, and offers the maximum of safety to the derrick man who exerts less energy in swinging the block to bring the elevators into position for handling drill pipe. The sheaves are of special alloy cast steel with grooves ground to A.P.I. specifications and dynamically balanced to assure free, non-surging rotation. Massive anti-friction roller bearings handle the tonnage with a margin of safety of 3 to 1. Regan dual bearings are embodied in each sheave. Further details upon request.

Regan

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Quality - Wrought on the Forge of Experience

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ity can then be worked out from the power characteristics of the engine and the proper gear reduction provided by the transmission, chains, sprockets, and line blocks, to give the desired work speed.

In the following paragraphs the different operations are assumed to be for the same depth wells but the various weights are approximate, as there is a difference in sizes and weights of rods, tubing, bailer, and line used.

Usually a well-servicing unit is used oftenest to pull rods. In all except the deepest wells, the weight of the rods can be lifted by a single line. In the portable type unit, the largest line used is a ⅞-in. The best grade has a maximum safe working load, friction allowed, of approximately 11,500 lb.

There is a limit to the speed at which rods can be pulled safely as well as a limit to the speed at which the workmen can function effectively. Under the best of conditions, this maximum speed is approximately 300 ft. per min. This speed is the same for the other operations, with the exception of the bailer, and it can be pulled as rapidly as is safe.

The operation next in importance is the pulling of tubing. Tubing weighs approximately three to four times as much as rods.

The other two operations are performed the least number of times. The combined pulling of rods, tubing, and fluid imposes a load four to five times heavier than rods. The pulling of bailer is the lightest, from 40 to 70 percent lighter than rods.

The increase in weight on the heavier operations to maintain the same work speed, as in pulling rods, would mean a like increase in torque. In the lighter operations, the reverse would hold — the decrease in weight would produce a like decrease in torque.

As the rod operation is the most important, it is, therefore, the logical yardstick to use in figuring the performance ability.

In figuring the performance ability of a unit that can lift 11,500 lb. from a standing start (the maximum safe working load of a ⅞-in. line at the predetermined speed of 300 ft. per min.), it is found that a unit of this size and weight is beyond the limit of portability. The limit of portability is approximately 5000 lb. from a standing start to 300 ft. per min. Consequently, whenever the weight is in excess of 5000 lb. there must be a sacrifice in speed, and it is the same when the performance ability is below these figures. Of course the decreasing load as the material is removed from the well should be taken into consideration.

General Characteristics

Because the weight varies in the different operations, there should be a proper gear ratio for each operation to obtain the best advantage of the power and speed produced by the engine.

In determining the engine characteristics, the torque should be large enough to handle at the desired work speed the maximum amount of work for the desired operation, including in this work the friction losses created by the bearings, gears, sprockets, chains and blocks, and allowing for one-third additional torque for starting.

The torque curve should be as flat as possible throughout the engine speed range. This will provide more pulling power at all speeds, because line pull is directly proportional to the torque. When high torque is developed over a wide range of speeds, the peak ability of the unit may be utilized at any line speed desirable or practicable within the range. Uniform acceleration, of course, requires uniform torque.

The most practicable engine for this type of operation will have already passed through its highest and most uniform torque before 1500 r.p.m. has been reached. The maximum hp. above 1500 r.p.m., therefore, is of very little importance compared with the actual net hp. at the peak of torque. As horsepower varies as torque × speed, engine horsepower at maximum torque determines the line speed at which the unit will lift its maximum weight.

Horsepower and Torque Formulas

The approximate net horsepower and torque in lifting a load from a standing start at the desired weights and line speeds can be calculated as follows:

Symbols

R = approximate line resistance through plain bearing blocks.
E = 75 percent efficiency of motor, transmission, sprockets, and chains.
W = weight to be lifted.
T = time in min.
L = length of pull in ft.
Hp. = horsepower.
33,000 = ft-lb. per min. in 1 hp.
1.333 = factor denoting one-third additional power required for starting load.

Approximate line resistance through plain bearing blocks:

No. of lines	*Resistance, percent*	*Factor*
1	2.5	1.025
2	5.0	1.05
3	7.5	1.075
4	10.0	1.10
5	12.5	1.125

Example: A string of tubing weighing 28,000 lb. is to be pulled from a well using 4 lines through blocks to a height of 80 ft. in 2½ min. How much power will be required to do the work?

Four-line resistance = 10 percent = formula factor 1.10.
1.10 × 28,000 = 30,800 lb.
30,800 ÷ 4 = 7700 lb. pull on power end of line.
As length of pull is 80 ft., power end of line will have to travel 4 × 80 = 320 ft.
7700 × 320 = 2,464,000 ft-lb.
33,000 × 2½ min. = 82,500 ft-lb.
82,500 × .75 = 61,875 ft-lb.
2,464,000 ÷ 61,875 = 39.82 hp.
⅓ additional hp. = 13.27; 13.27 + 39.82 = 53.09 = total hp. required.

The complete short formula: $\frac{1.33 \times R \times W \times L}{T \times 33{,}000 \times E}$ = total hp. required.

$$\frac{1.33 \times 1.10 \times 28{,}000 \times 80}{2.5 \times 33{,}000 \times .75} = 53.09 \text{ hp.}$$

Torque required at engine speed desired. For instance, at 840 r.p.m.

$$\frac{53.09 \times 33{,}000}{2 \times \pi \times 840} = 336 \text{ lb.-ft.} = \text{required torque.}$$

Proper Gear Ratio

To find the proper gear ratio when the following factors are known: drum barrel radius; lift in ft.; number of lines, and motor r.p.m. at the required torque.

$$\text{Formula: Drum r.p.m.} = \frac{\text{number of lines} \times \text{length of pull} \times 12}{\text{time in min.} \times \text{rolling radius} \times 2 \times \pi}$$

$$\text{Total gear reduction} = \frac{\text{engine r.p.m.}}{\text{drum r.p.m.}}$$

Example:

$$\frac{4 \text{ lines} \times 80 \text{ ft. length of pull} \times 12}{2.5 \text{ min.} \times 6.5 \text{ rolling radius} \times 6.28} = 37.63 \text{ r.p.m.} = \text{drum speed.}$$

$$\frac{840 \text{ r.p.m.}}{37.63} = 22.32 = \text{total gear ratio.}$$

OLIN G. BELL, division production geologist of the Humble Oil and Refining Company, Houston, Texas, was guest speaker at a meeting of the Texas A. & M. College Student Chapter of the American Institute of Mining and Metallurgical Engineers, held November 23 on the college campus at College Station.

Bell spoke on "The Function of a Production Geologist." In his lecture, he discussed the relationships between various departments in a large oil company and explained what students might expect when they start working for a large oil company. The lecture was followed by an open forum discussion.

JACK BALLAGH, of the Patterson-Ballagh Corporation, accompanied Bell to the college.

WILLIAM R. MITCHELL, president of the Mitchell-Stewart Construction Company, pipe-line contractors, Dallas, Texas, died recently after an extended illness. Mitchell was a native of Scotland and had been active in pipe-line construction work since 1907. Before forming the Mitchell-Stewart Construction Company he was associated with **EDWIN A. MACPHERSON.**

J. G. DYER, vice-president in charge of drilling for the Continental Oil Company, has announced formation by his company of an oil pipe line and terminal division and an oil trading division, resulting in the promotion of several employees. **A. C. WILKINSON,** superintendent of the Oklahoma-Kansas division, has been appointed superintendent of the oil pipe line and terminal division. He will have his headquarters at Ponca City, Oklahoma. **T. A. VAN GRIETHUYSEN** has been named superintendent of the oil trading division. **IRA D. PIERSON,** production superintendent of the Montana district, has been made assistant general superintendent at Denver, Colorado. A Colorado production district has been formed and **H. C. RANKIN** transferred from Shiprock, New Mexico, to Denver to take charge. **GEORGE COX,** district superintendent at Florence, Colorado, replaces Rankin at Shiprock. **J. C. THOMAS** has been named superintendent of the Montana district and will have his headquarters at Billings. **W. C. RICE,** superintendent of the eastern Wyoming district, is now superintendent in charge of operations of the entire state.

J. G. MANLEY, geologist for the Standard Oil Company of Venezuela, is in the United States on a short visit.

EDGAR DAVIS, of Lethbridge, Altamont, Canada, has joined the engineering staff of the International Petroleum Company in Ecuador, South America.

B. W. GILLESPIE, who has been employed by the Argentine Government as a technical adviser, is spending a vacation in California. He is accompanied by his family.

W. K. HALEY, superintendent, Barnsdall Oil Company, has been transferred from Tulsa, Oklahoma, to Mankins, Texas.

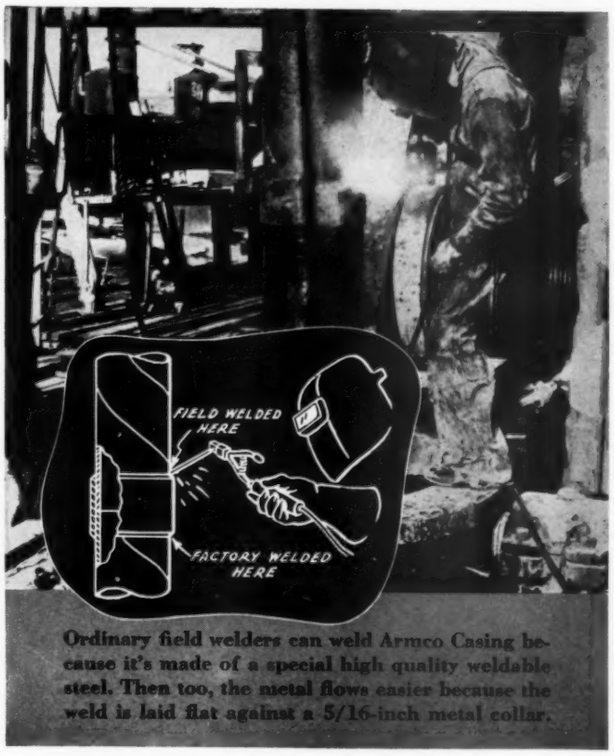
W. R. CAMPBELL, geologist for the Tropical Oil Company, Barranca Bermeja, Colombia, South America, is now at Berkeley, California.

HENRY R. KIMBLE, geologist, Magnolia Petroleum Company, has been transferred from Dallas, Texas, to the staff of the Socony-Vacuum Oil Company at Caracas, Venezuela.

JOHN McFAYDEN, vice-president of the Ohio Oil Company, who has been stationed at Casper, Wyoming, is now making his headquarters at Los Angeles, California.

YOU GET A TIGHTER JOINT

AT LESS EXPENSE



Ordinary field welders can weld Armco Casing because it's made of a special high quality weldable steel. Then too, the metal flows easier because the weld is laid flat against a 5/16-inch metal collar.

• Thrifty oil men everywhere are discovering that Armco Slip-Joint Casing is a real money-saver for conductor lines that are cemented in and never pulled.

One big reason is that Armco Casing eliminates the unnecessary expense of threaded ends. This saves you $29 a joint on 13⅜-inch, 48-pound pipe—a total saving of $580 in 600 feet, which more than offsets the cost of field welding. Besides, the field-welded slip joint gives you a tight, leak-proof connection with plenty of strength to withstand the conditions met in surface strings.

You'll also find Armco Casing easier to handle and set because it's free of excess weight. No special slips or elevators are required and each length lines up accurately in the slip-joint collar without need for special clamps. For immediate delivery of Armco Casing in standard sizes, just call the nearest store of our distributor, or address: The American Rolling Mill Co., Pipe Sales Division, Middletown, Ohio; 538 Mayo Bldg., Tulsa, Okla.; 3500 Maury St., Houston, Texas.

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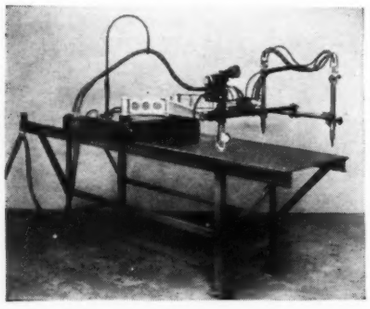
MACHINERY and EQUIPMENT

Airco No. 10 Planograph

THE extreme flexibility of the new Airco No. 10 Planograph announced by Air Reduction Sales Company, New York, New York, is demonstrated by its ability to gas-cut straight lines, rectangles, circles, and irregular shapes from ferrous metal of any thickness within the present practicable limits of the cutting torch. Although a stationary-type machine, the new unit can readily be moved by crane to different localities in the shop.

The No. 10 Planograph consists of a tracing table upon which the carriage travels. The torches and tracing devices are supported on the carriage. Operating on either 110 or 220 volts a.c.



or d.c., the unit requires a minimum of floor space. Including the work table, the new planograph requires a working area of only 5½ ft. by 10½ ft.

Cutting range in single torch operation is 24 in. wide by 72 in. long. This length can be increased indefinitely in multiples of 72 in. by utilizing additional tracing tables. Maximum diameter of circle cuts is 24 in. When two torches, mounted on the regular operating bar, are employed for simultaneous cutting, the cutting area for each torch is 12 in. wide by 72 in. long. Two circles, both to 12 in. diameter, can also be cut with the torches mounted in this manner. By using an auxiliary bar, the cutting area of each is 24 in. by 24 in.

The tracing device for manual tracing can be locked so that it will, without manual guiding, travel in a straight line in any desired direction. This time-saving feature is particularly convenient when cutting any irregular shapes that involve straight-line cutting. The devices for magnetic and templet tracing can be quickly interchanged in the existing head. The magnetic tracer, connecting directly to an electrical outlet conveniently placed near the top of the tracing device head, requires 110-volt d.c. for operation.

Provision is also made at the tracing device head for connecting a lamp to light the work table. A switch for forward and reverse motion, and the magnet switch, are also conveniently situated at this point. The speed of the motor is governed by a graduated disk called the index speed control. This disk provides a complete range of motor speed in one full turn of 360°. The cutting speed in in. per min. is registered on the reversible tachometer.

The gas control unit on the No. 10 Planograph is centrally situated. A knob handle operates cams, progressively arranged, one each for the pilot light, acetylene (or other fuel gas), oxygen preheat, and cutting oxygen. One complete cycle lights and cuts off in proper sequence. Handwheels mounted on either end of this unit permit lighting or extinguishing the torch from either end of the tracing bar. For further information concerning the Airco No. 10 Planograph write Air Reduction Sales Company, 60 East 42nd Street, New York, New York.

Allis-Chalmers Extends Texrope Drive Line

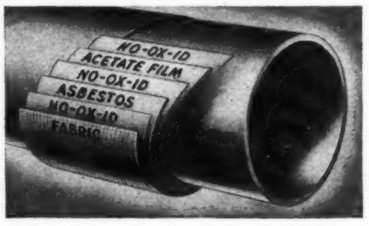
ALLIS-CHALMERS Manufacturing Company, Milwaukee, Wisconsin, has extended its line of Texrope demountable rim type sheaves to certain sizes carried in stock and a range of sizes which can be made promptly to order. These cast-iron sheaves all consist of a substantial bushing on which may be mounted a sheave rim of desired number of grooves and pitch diameter.

This demountable rim type sheave was originally introduced primarily for use on oil-field equipment; however, since this type provides an easy method for changing sheaves without removing the hub from the shaft, it can be used to advantage for any application requiring a limited number of fixed steps in speed change. These sheaves, more fully described in leaflet B-6041, are available for use with "C" and "D" section belts.

Reinforced Asbestos Wrapper

AN improved asbestos wrapper for protecting underground pipe lines against physical and chemical action has been developed by Dearborn Chemical Company, Chicago, Illinois.

This new product, No-ox-idized reinforced asbestos wrapper, has greater tensile strength, dielectric strength, and moisture-resisting properties than other asbestos wrappers made by the



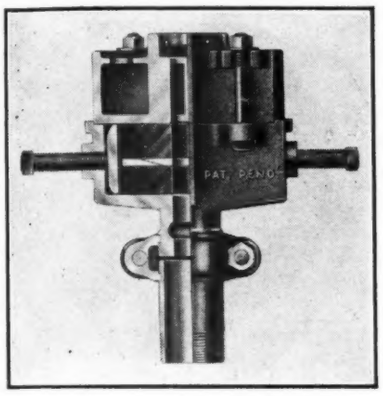
company, but is pliable enough to cover pipe joints and other irregular surfaces without cracking, it is asserted. The new wrapper is resistant to soil action and impervious to fungus growth, according to the manufacturer.

Like the No-ox-idized asbestos wrapper, this new wrapper has a heavy asbestos layer impregnated with No-ox-id. In addition, it is reinforced with a light fabric and with a layer of acetate membrane covered on both sides with No-ox-id. The purpose of these extra laminations is to improve density and mechanical strength and also to provide a higher resistance to moisture penetration. The weight of the wrapper has not been appreciably increased. It can be applied by hand or by machine.

Polished-Rod Stuffing Box

THE American Iron and Machine Works Company, Oklahoma City, Oklahoma, and Houston, Texas, announces an improved and simplified polished-rod stuffing box. The major improvement, it is asserted, is the two-piece construction of this box.

The top part—the oil reservoir—can be easily detached and lifted from the lower section, which houses the pol-



ished-rod rubbers. By lifting the top section of the box, old polished-rod rubbers can be removed easily and quickly, thus making the installation of new rubbers a simple matter; this new construction also results in a considerable saving of time, it is stated.

American polished-rod rubbers are constructed with a special lead insert, designed to eliminate the pitting and scoring of polished rods. Even when the polished rod is already in pitted or scored condition, use of the new American polished-rod stuffing box, it is asserted, will restore the rod to its original smoothness.

The American stuffing box is manufactured in the wobbler type, for straight-lift purposes.

Koroseal Paint

AGAIN extending the use of its recently introduced synthetic elastic, Koroseal, The B. F. Goodrich Company, Akron, Ohio, announces a new Koroseal paint, designated as No. 495 Korolac, the name covering solutions of the plasticized poly-vinyl chloride whose basic materials are coke, limestone, and salt, and which were developed in the Goodrich laboratories. A Korolac primer for use with the new paint is also introduced.

The new paint gives a semi-glossy black finish and is recommended wherever extremely corrosive conditions prevail. Applied to metal surfaces after they are prepared as for any other kind of paint or lacquer, the primer forms a strong bond between the Korolac and the metal itself.

Korolac No. 495, when thoroughly dry, will withstand all acids, alkalies, and salts in the concentrations commonly encountered in industry, to temperatures of 150°F., the manufacturer asserts.

It is not affected by chrome, nickel, cadmium, zinc, copper, brass, silver, or tin plating solutions, nor are such solutions contaminated or fouled by the paint when it is thoroughly dried, it is stated.

Ordinary atmospheric conditions have no effect on the paint; it is extremely moisture resistant; the dried film is hard and resistant to abrasion, yet sufficiently elastic to conform to contraction and expansion of the support, the makers state.

Both the primer and the paint can be applied by brushing or spraying.

Dowell Acid Jet Gun

N. R. CRAWFORD, general manager of Dowell Incorporated, Midland, Michigan, and Tulsa, Oklahoma, announces the introduction of a new tool called the Acid Jet Gun.

Crawford asserts that the scope of chemical service for oil and gas wells, so vital to the oil-producing industry, has been greatly expanded through the development of the Acid Jet Gun. According to Crawford, the tool increases the scope of acidizing by making possible the treatment of wells heretofore considered untreatable and by greatly improving the technique of acidizing.

Introduced and perfected by Dowell, the Acid Jet Gun is designed to be run on the end of, or as a section of, the regular tubing string. It may be used in conjunction with various auxiliary chemicals, packers, circulating tools or release valves and may be raised, lowered, or rotated during the process to accord effective jetting on the entire section desired to be treated.

It is further asserted that this tool permits streams of acid to be shot horizontally or vertically against the walls or bottom of the well bore. The acid is projected through small-diameter nozzles, designed for effectively removing Dowmetal pipe, cement, lime, and calcareous deposits at a distance of 15 in. from the nozzle. This action, it is said, may be obtained under fluid such as oil, water, acid, or any fluid of approximately the same viscosity as acid, at 1000 lb. per sq. in. differential pressure across the jets.

"This special tool offers many advantages," said Crawford. "By its use a high degree of mechanical efficiency is added to the chemical treating solutions. This results in a more economical and efficient treatment of oil and gas wells."

"Speaking of specific uses for the Acid Jet Gun," Crawford continued, "This new tool, which is now available to oil producers everywhere, is indispensable for a number of important operations. It removes cement or mud sheaths from the walls of a well, jets-out portions of a cement plug, and cleans any type deposits from the face of the pay. Paraffin deposits may be removed from a well by jetting Dowell Paraffin Solvent through the gun. Perhaps one of its most interesting uses is its application for quickly removing Dowmetal pipe and the cement behind it. It also finds important application in liner or screen perforation cleaning, in deepening a well in limestone formations, and removing lime cavings."

"The acidizing of producing formations, in fact the entire acidizing technique, is now greatly improved," continued Crawford. "This new tool of ours offers a positive means of mechanically directing the acid to the exact spot to be treated. Thus the scope of our operations has been extended widely."

Ingersoll-Rand Gas-Engine Compressor

INGERSOLL-RAND Company, New York City, announces a new heavy-duty, gas-powered compressor known as the "LVG". Designed to fill the growing need for large, compact, 4-cycle units, the LVG is built in 485 and 650 hp. sizes using 6 or 8 V-type power cylinders, the makers state. By using only two compressor frames on either size, the inlet, discharge, and inter-stage piping and manifolding are simplified, and only two stuffing boxes are required.

The LVG incorporates overhead valves and removable wet-type liners in the power cylinders. All auxiliaries, including the camshaft, the built-in recirculating water pump, and auxiliary power take-off are driven from the flywheel end of the shaft, a feature promoting good governing and smooth operation, it is asserted.

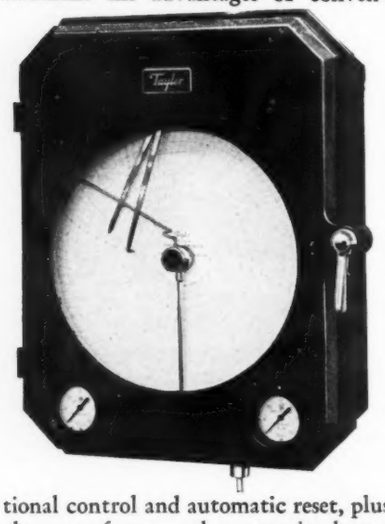
Lubrication is full force-feed, with continuous oil cooling and oil filtration. Power pistons have oil-cooled crowns. Governing provides for manual or automatic speed control to half-speed.

The manufacturer supplies LVG compressors and suitable cylinders for pressures to 5000 lb. and for vacuum service.

Ingersoll-Rand further announces that the V-type cylinder power end of these units is available as a straight gas engine, known as the PLVG.

Taylor Fulscope Controller

THE Taylor Fulscope Controller, a new air-operated controller, makes available in one highly adaptable instrument the advantages of conventional control and automatic reset, plus the new features that promise better all-around performance under the difficult operating conditions encountered in refineries and gasoline plants, it is stated by the manufacturer.



Introduced by the Taylor Instrument Companies, Rochester, New York, this new Fulscope Controller offers automatic reset inside the case and wider range of adjustments. Maximum ease in making adjustments is assured by the use of a magnified dial, calibrated in absolute units.

The new Taylor Fulscope Controller can be changed from direct- to reverse-acting in the field with no change of mechanism. Precalibrated actuating systems are available, as always, and easier than ever to install, it is asserted. The universal case for face or flush mounting is drilled and tapped to accommodate the simplest or the most complex form of control. Conversion from one form of control to another is easily done in the field by the addition or substitution of unit assemblies.

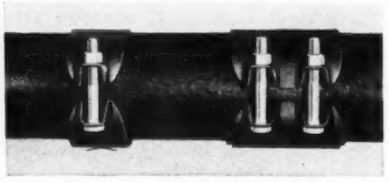
Consistent performance throughout the entire sensitivity range is assured because of completely pneumatic sensitivity reduction, it is stated. The relation between pointer movement and output pressure is so linear that the instrument may be used as a remote transmitter.

The new Fulscope Controller gives the user a choice of five general types of instrument, each type suited to certain applications. These include instruments for fixed high sensitivity, adjustable sensitivity, and automatic reset. To these three conventional types have been added two new ones, using Pre-Act, a third effect that goes beyond ordinary control performance, the makers state. Pre-Act is offered for the first time in easily adjustable form as one of the standard units of a controller. The simplicity of the new design plus the extensive use of 18-8 stainless steel results in long, trouble-free performance, and accessibility and interchangeability of parts make maintenance easy, it is pointed out.

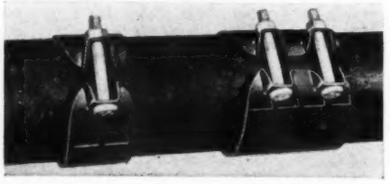
Other improvements in design include: New electric clock having all gears immersed in oil, also available in explosion-proof housing; spring-driven clock optional. Inbuilt, easily cleaned air filters supplement the large external filter and drip well. Improved rapid chart changing mechanism. Neoprene gaskets used throughout. Same control mechanism for temperature, pressure, rate of flow, and liquid level.

Skinner Clamp Now Available Perforated

THE M. B. Skinner Company, South Bend, Indiana, makers of a complete line of pipe leak repair clamps, announce that hereafter their Pressed Steel Economy Clamp will be available with perforations in the gasket half to facilitate welding this on as a patch. Illustrations tell the story.



Skinner-Seal pressed steel economy clamp—regular type. Supplied in narrow width (3½ in.) with rubber cone plug riveted in, for repair of pit holes—and double width (6½ in.) with strip gasket, for elongated corrosion spots



New perforated type of pressed steel economy clamp. The half clamp containing gasket is perforated, so that after sides are welded, lugs may be broken off to simplify completing the weld

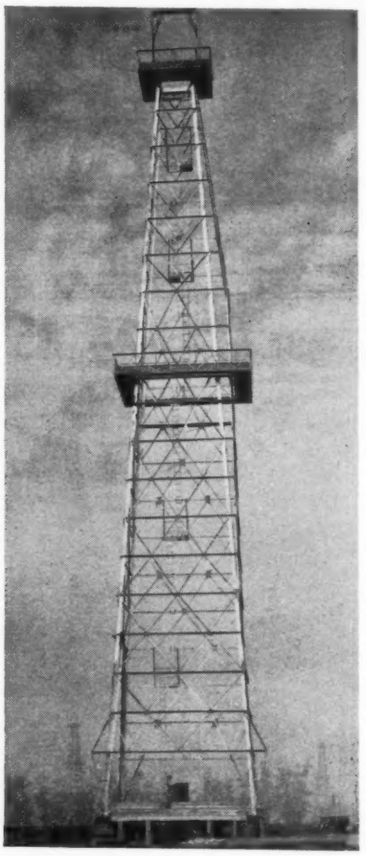
Drillable Button Screen

McEVOY COMPANY, Houston, Texas, has announced a drillable Button Screen made of Securaloy pipe having Securaloy Buttons to permit economical reworking of clogged wells. If the screen is stuck so that it cannot be pulled when reworking is necessary, it can be completely drilled-out in a short time, it is stated, making fishing job unnecessary.

McEvoy Drillable Button Screen is available with either flush or coupled joints, and is especially recommended by the manufacturer for deep wells or wells in which silt clogging is a serious problem.

"Bulge Type" Derrick

THE new 136-ft., 26-ft. base Consolidated galvanized derrick shown here is the first of a new design developed by Stoddard-Rawson, Inc., engineers, Los Angeles, California. The derrick is known as the "Bulge Type," which rises nearly vertically on one side to provide 50 percent more racking area at the finger. The point at which the taper of the two legs forming the bulge changes is 94 ft. above the base. This allows for handling 90-ft. stands in the enlarged racking area.

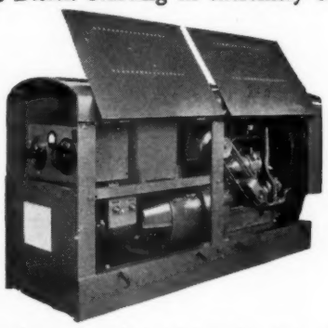


This particular derrick is constructed of ninth weight carbon steel, 576,600 lb. A.P.I. safe load. The well on which the derrick is erected is St. Anthony Oil Company's No. 1 Gordon in the Rosecrans field, California. Derricks for deeper wells will be of specified height and base, having increased capacity and different steel.

Diesel-Engine-Driven Arc-Welder

A NEW 300-amp. Diesel-engine-driven arc-welder, equipped with gasoline-engine starting, is announced by The Lincoln Electric Company, Cleveland, Ohio.

The gasoline engine used for starting the welder is a small auxiliary mounted above the Diesel engine. It is started by means of a hand crank. A belt drive, engaged by means of a clutch, connects the starting engine to the Diesel. Starting in extremely cold



weather is facilitated by the fact that the cooling system of the small gasoline starting engine is connected into the cooling system of the Diesel. This arrangement makes it possible to warm-up the Diesel by running the starting engine a short time and allowing the heated water to circulate through the Diesel engine.

The new Lincoln Diesel-driven welder is said by the manufacturer to reduce fuel cost 33 to 86 percent, depending upon the type of fuel oil used. The Diesel uses only 1.5 gal. of fuel oil per hour at full load operation, it is stated.

The arc-welding generator used on the new welder is the 300-amp. "Shield Arc SAE" unit, equipped with dual continuous control.

The frame of the arc-welding generator is attached directly to the Diesel engine bell housing. The generator shaft is connected to the engine flywheel by a special type flexible coupling. Mounting for the entire unit is provided by a substantial channel frame.

Worthington Turbine Well Pumps

A NEW line of Turbine Well Pumps is announced by the Worthington Pump and Machinery Corporation, Harrison, New Jersey. For use in bored wells, these new units feature vacuum molded impellers—the first time this construction has been used in this type of pumping equipment, the makers state.

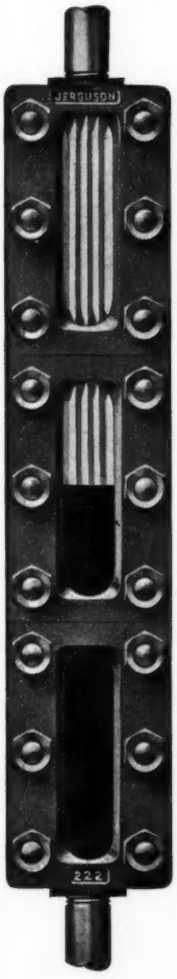
Vacuum molded impellers are said to be in perfect balance, and the smoothness of the blade surfaces and uniformity of the castings result in high efficiency and certainty of performance. Abrasion of the impellers is reduced to a minimum by the use of hard, high-tensile bronze. Available with either enclosed oil-lubricated or open water-lubricated shaft bearings, these new turbine well pumps are readily adaptable to individual local conditions, it is stated.

Details of construction are illustrated in Worthington bulletin H-450-B29. A companion bulletin, H-450-B30, deals particularly with the vacuum molded impellers used in these pumps.

Hercules Offers Stripper-Type Tubinghead

THE Hercules Tool Company, Tulsa, Oklahoma, is now in production on its new stripper-type tubinghead, known as "Type K." Its outstanding feature is the low cost of stripper-rubber replacement, the manufacturer states. "Snubbing-in" of tubing is eliminated. The head is constructed of electric steel throughout, and is recommended for 2000-lb. test pressure. The new head is fully described in the company's new Bulletin No. 36.

JERGUSON



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Speed Increasers

A NEW line of speed increasers for operating centrifugal pumps, high-speed blowers, and compressors, and for pipe-line service, has been announced by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania. Standard gear ratios vary from 2 to 1 to 12 to 1, and these new units are available in ratings of from 1 hp. per 1000 r.p.m. of the high-speed shaft to more than 1800 hp. per 1000 r.p.m.

Speed increasers can be supplied for either right- or left-hand assembly. Sleeve bearings have been designed to provide low unit pressures and assure permanent alignment at minimum friction loss. Lubrication is accomplished by a self-contained circulating oil system, including a circulating pump, an oil cooler, strainer, relief valve, and sight flow indicator. Gears are spray-lubricated at the line of contact; all bearings are under pressure lubrication. Frames are split horizontally to permit easy access to all internal parts, and each unit has an easily removable inspection plate. Average efficiency of these units is greater than 96 percent, the manufacturer states.

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JACOBS WIND ELECTRIC CO., INC.

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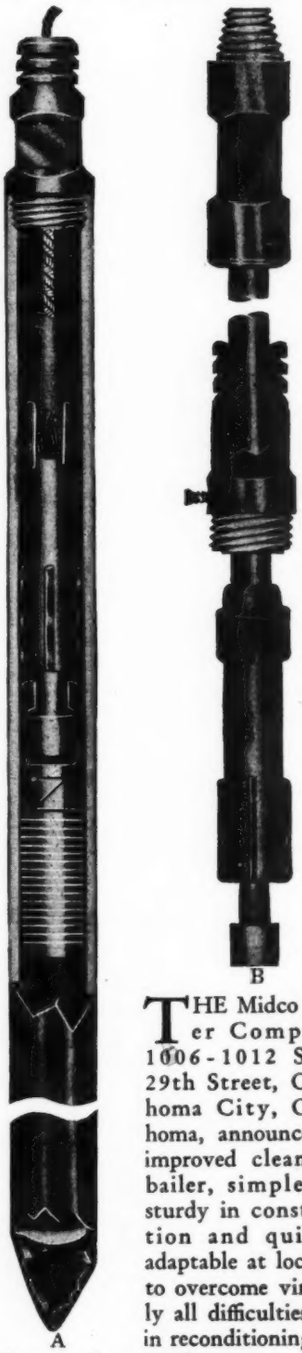
Oil-Well Clean-Out Tool



THE Midco Bailer Company, 1006-1012 S. E. 29th Street, Oklahoma City, Oklahoma, announces an improved clean-out bailer, simple and sturdy in construction and quickly adaptable at location to overcome virtually all difficulties met in reconditioning, according to the manufacturers.

The complete assembly (A), as shown in an accompanying illustration, is equipped with sand-line head and large-opening bottom. It is light enough to be run on a sand line and sturdy enough to withstand the most severe treatment, it is stated.

The tool head (B) can be quickly and easily installed at any time deemed advisable. This head permits jars and sinker to be run above the bailer, thus adding weight and permitting the operator easily to free the bailer if it should become stuck in the hole.